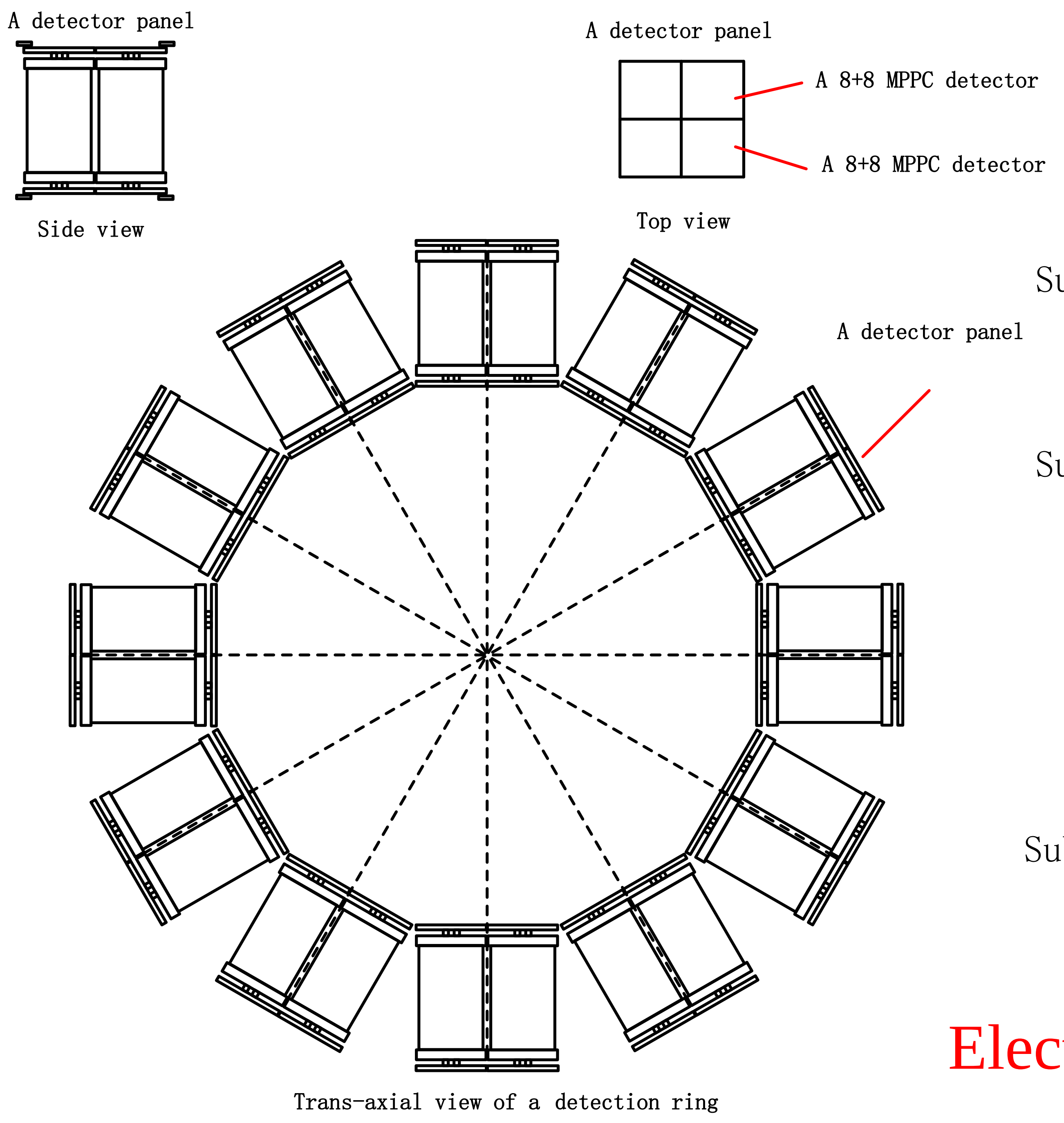
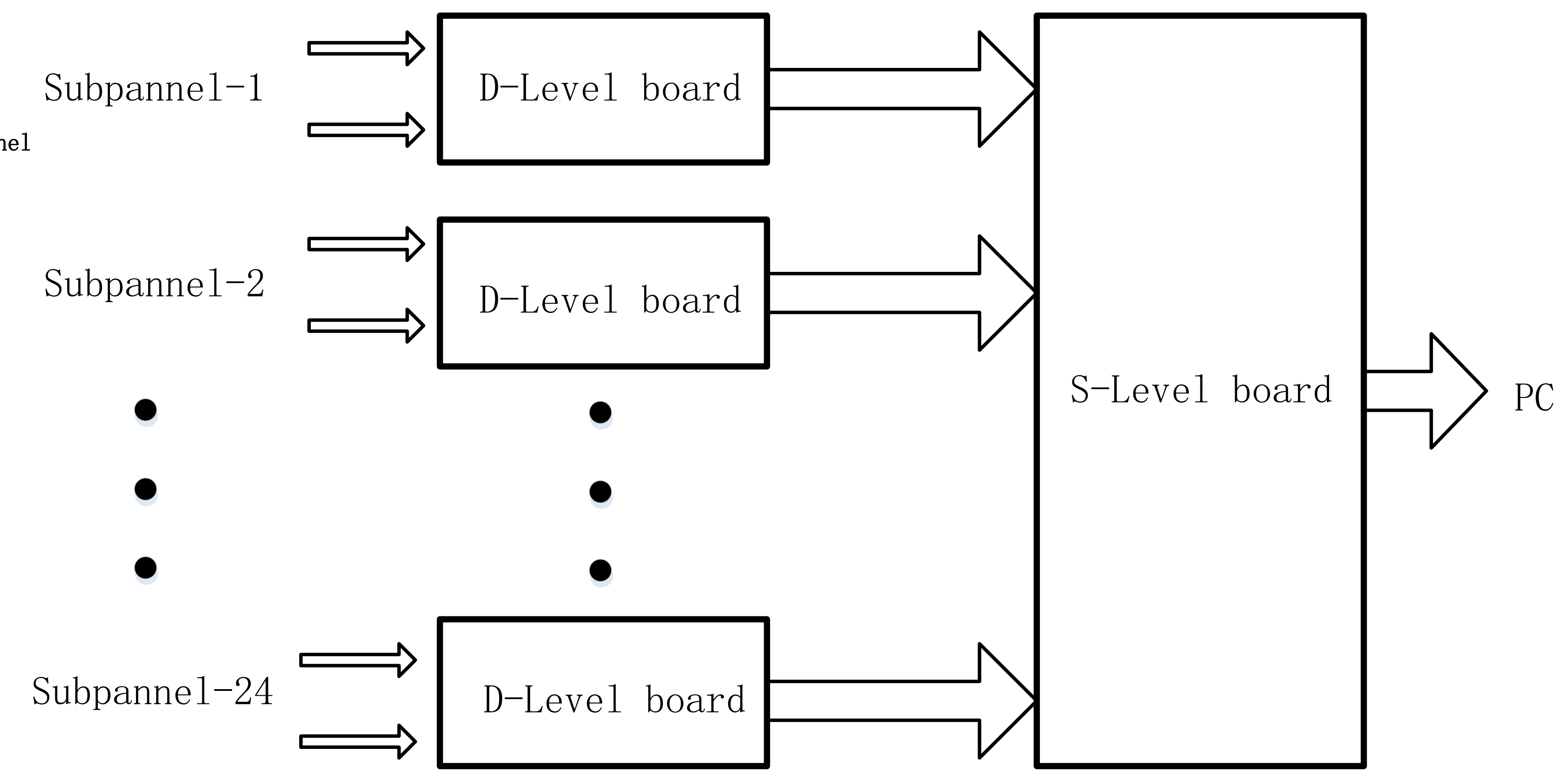
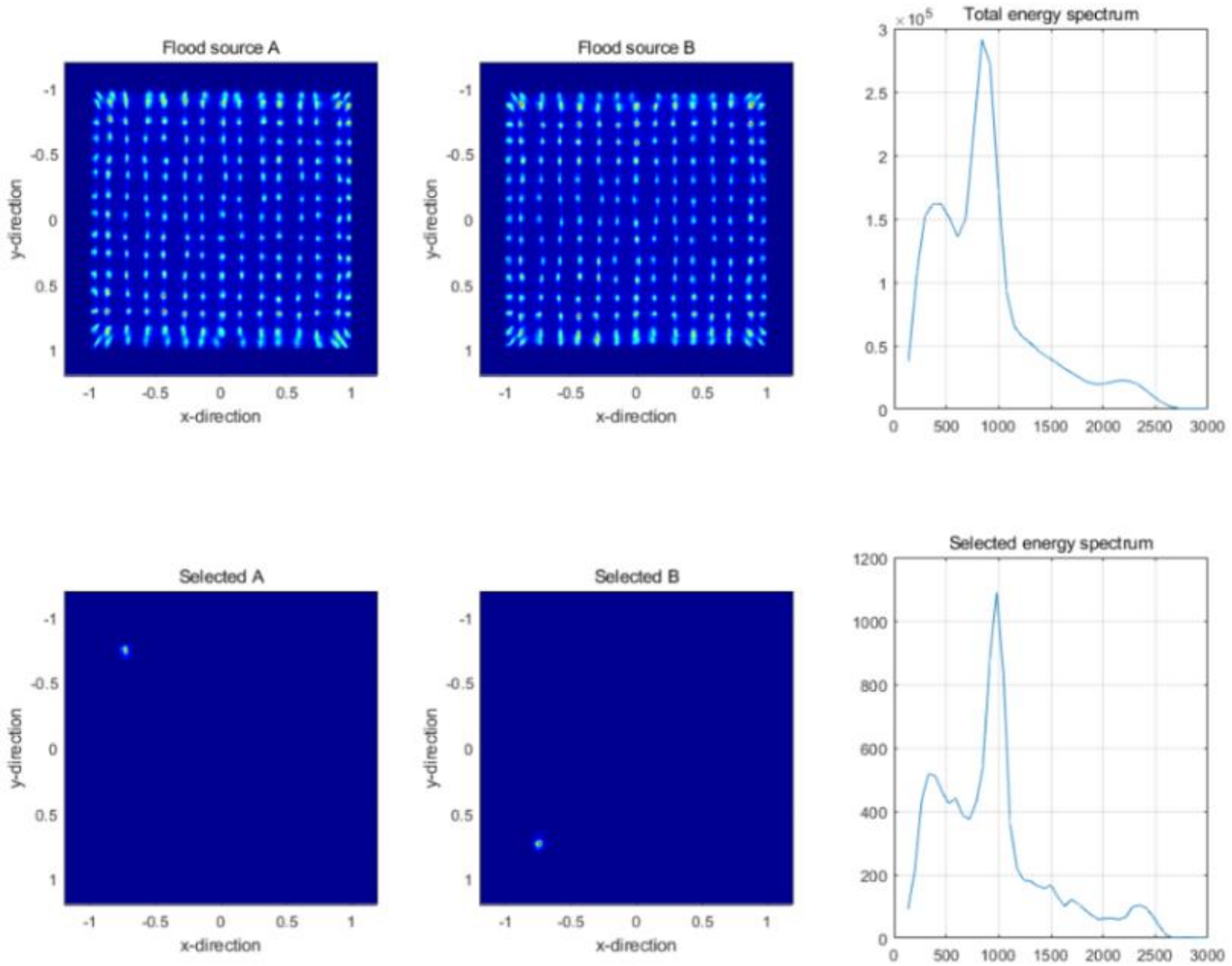
A novel real-time radiation detector readout and acquisition system for PET







Detectors:

I. 12 detector panels;

II. A detector panel:

1. eight 8+8 MPPC arrays ;
2. four 15×15 LYSO arrays.

Electronics:

I. 12 Dlevel boards + 1 Slevel board.

II. Detector level (D-level) board:

1. Sigma Delta Modulation Method
2. 64 channels

III. System level (S-level) board:

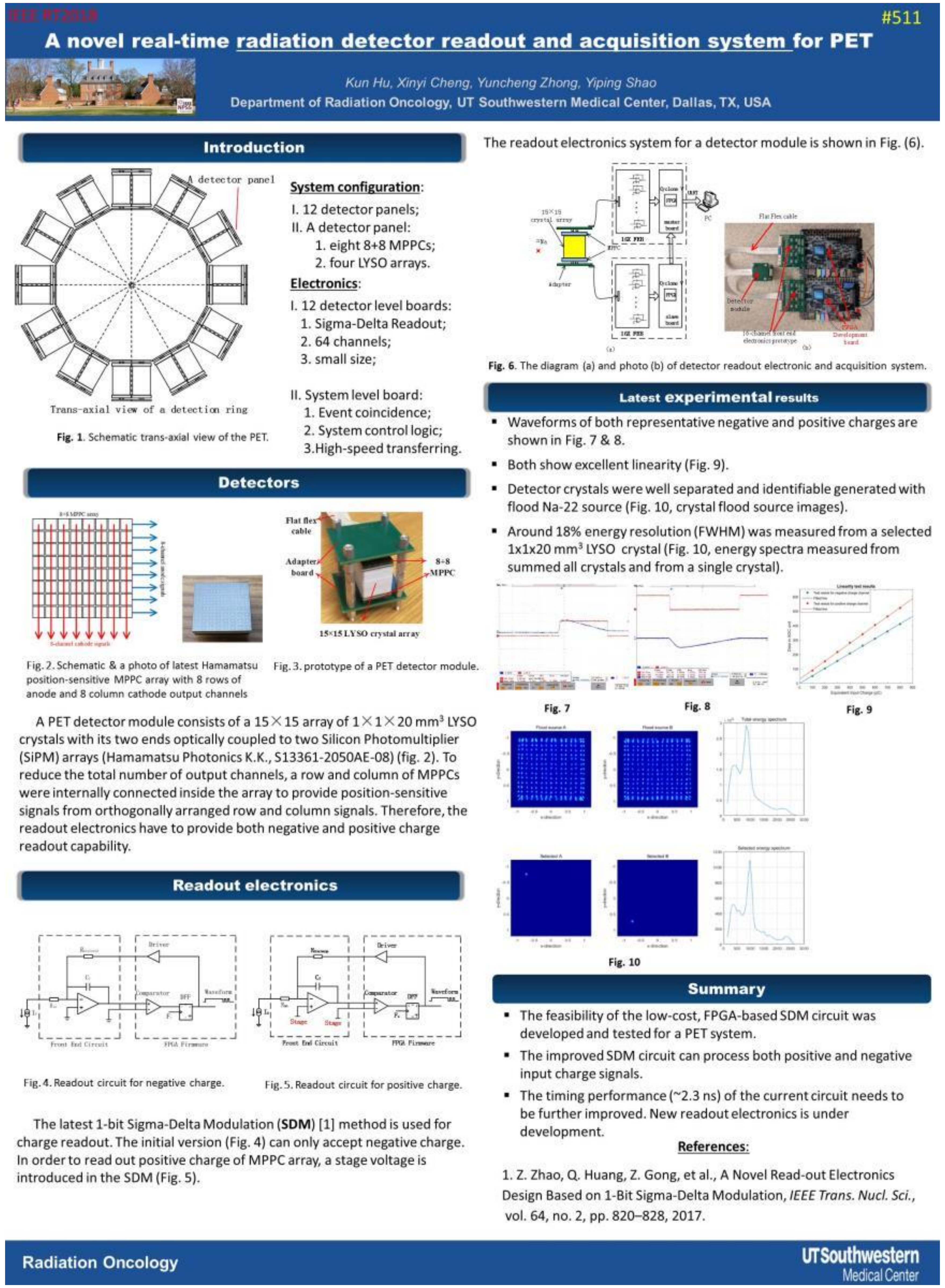
1. Event coincidence & buffer
2. High speed data transferring

Results:

I. Good flood source;

II. Good energy resolution(~18%).

Poster #511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#511

A novel real-time radiation detector readout and acquisition system for PET

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Introduction

A detector panel

Trans-axial view of a detection ring

Fig. 1. Schematic trans-axial view of the PET.

System configuration:

I. 12 detector panels;

II. A detector panel:

1. eight 8*8 MPPCs;
2. four LYSO arrays.

Electronics:

I. 12 detector level boards:

1. Sigma-Delta Readout;
2. 64 channels;
3. small size;

II. System level board:

1. Event coincidence;
2. System control logic;
3. High-speed transferring.

Detectors

Flat flex cable

Adapter board

8×8 MPPC

15×15 LYSO crystal array

Fig. 2. Schematic & a photo of latest Hamamatsu position-sensitive MPPC array with 8 rows of anode and 8 column cathode output channels

Fig. 3. prototype of a PET detector module.

A PET detector module consists of a 15×15 array of 1×1×20 mm³ LYSO crystals with its two ends optically coupled to two Silicon Photomultiplier (SiPM) arrays (Hamamatsu Photonics K.K., S13361-2050AE-08) (fig. 2). To reduce the total number of output channels, a row and column of MPPCs were internally connected inside the array to provide position-sensitive signals from orthogonally arranged row and column signals. Therefore, the readout electronics have to provide both negative and positive charge readout capability.

Readout electronics

Fig. 4. Readout circuit for negative charge.

Fig. 5. Readout circuit for positive charge.

The latest 1-bit Sigma-Delta Modulation (**SDM**) [1] method is used for charge readout. The initial version (Fig. 4) can only accept negative charge. In order to read out positive charge of MPPC array, a stage voltage is introduced in the SDM (Fig. 5).

The readout electronics system for a detector module is shown in Fig. (6).

Fig. 6. The diagram (a) and photo (b) of detector readout electronic and acquisition system.

Latest experimental results

- Waveforms of both representative negative and positive charges are shown in Fig. 7 & 8.
- Both show excellent linearity (Fig. 9).
- Detector crystals were well separated and identifiable generated with flood Na-22 source (Fig. 10, crystal flood source images).
- Around 18% energy resolution (FWHM) was measured from a selected 1x1x20 mm³ LYSO crystal (Fig. 10, energy spectra measured from summed all crystals and from a single crystal).

Fig. 7 **Fig. 8** **Fig. 9**

Fig. 10

Summary

- The feasibility of the low-cost, FPGA-based SDM circuit was developed and tested for a PET system.
- The improved SDM circuit can provide both positive and negative input charge signals.
- The timing performance (~2.3 ns) of the current circuit needs to be further improved. New readout electronics is under development.

References:

1. Z. Zhao, Q. Huang, Z. Gong, et al., A Novel Read-out Electronics Design Based on 1-Bit Sigma-Delta Modulation, *IEEE Trans. Nucl. Sci.*, vol. 64, no. 2, pp. 820–828, 2017.

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