Performance characteristic of Total Body J-PET prototype with plastic scintillator and Wavelength Shifters

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Abstract

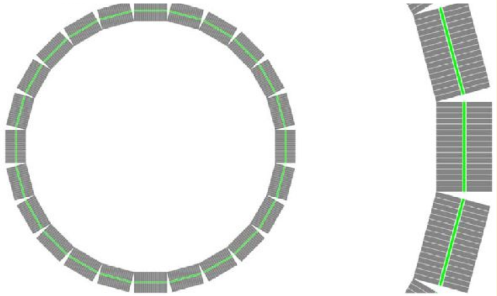
Positron Emission Tomography is currently one of the most used non-invasive imaging techniques that provides methods to determine and monitor stage of tumor and assessment of a response to the treatment [1].

- The purpose of the presented investigations is to design, construct and establish the characteristic performance of the Total Body J-PET (TB J-PET).

- Its construction is based on a novel idea of PET detector constructed with plastic scintillators and wavelength shifters (WLS).

Introduction

Fig.2. Visualisation of the simulated 2-layer 24-module 2 m long TB-J-PET scanner. Scintillator strips are marked in gray and WLS strips in green.



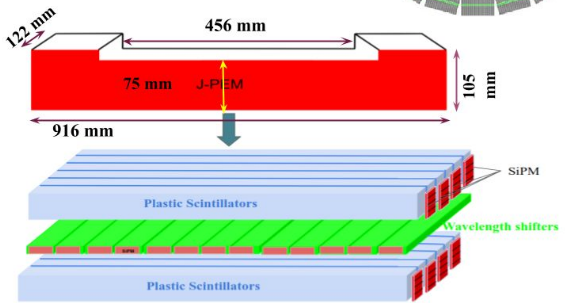


Fig.2. One the considered design of total body J-PET. Consist of Scintillator strips are marked in blue and WLS strips in green.

Methods and materials

This study characterizes the performance of a newly developed TB J-PET scanner prototype

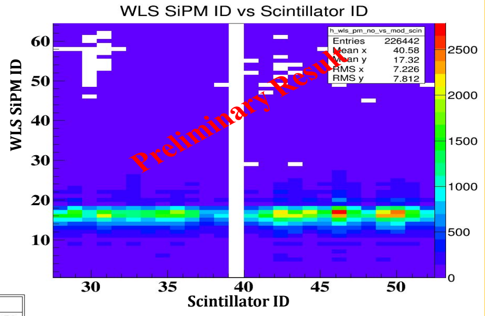
- The prototype system consists of a single module of plastic scintillators, built from two layers of plastic scintillator (6x24x500 mm) [2,3] and the wavelength shifters (3x10x100 mm) [4,5].

- Each scintillator bar is attached at both ends to silicon photomultipliers for the signal readout .

- Data processing will be handled by specifically developed front-end boards based on field-programmable gate array (FPGA) chips.

Results

Fig.3 Distribution of of WLS SiPM ID over the scintillator ID (Righ). Source was placed at the center with slit width 4mm



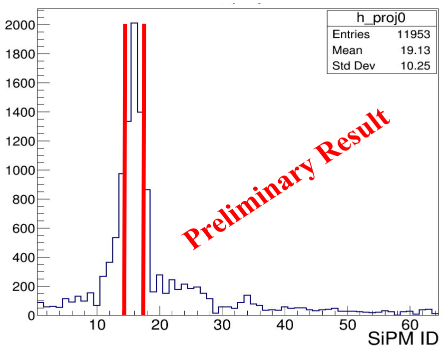


Fig.4. One of the y projection of above histogram. Analysis of a raw data without any cut and tune in we are able to get 15 mm of z resolution.

Simulation Result

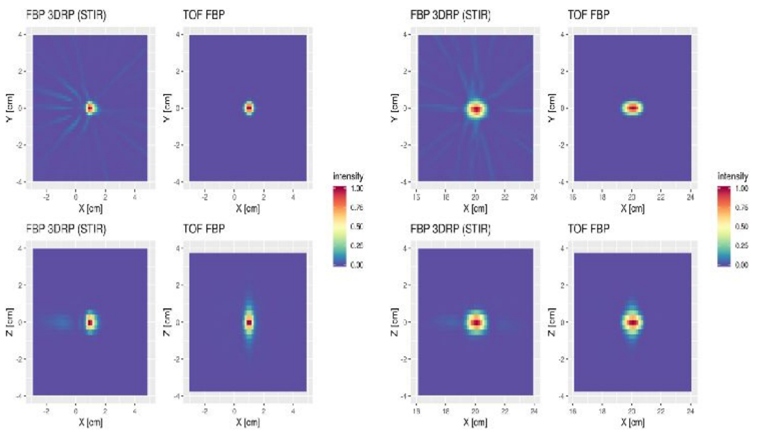


Fig. 5. Example of transversal cross sections of images reconstructed for point sources positioned as indicated above the pictures (x, y, z). Spatial resolutions(SRs) of 3.7 mm (transversal) and 4.9 mm (axial) are achieved [6].

Discussions

In general we observed that in the center of the considered TB-J-PET scanner the radial and tangential resolution is better than 4.9 mm independent of the scenario and that the axial resolution varies between PSF = 4.8 mm (for the ideal case) and PSF = 7.8 mm (for the unknown DOI).

References

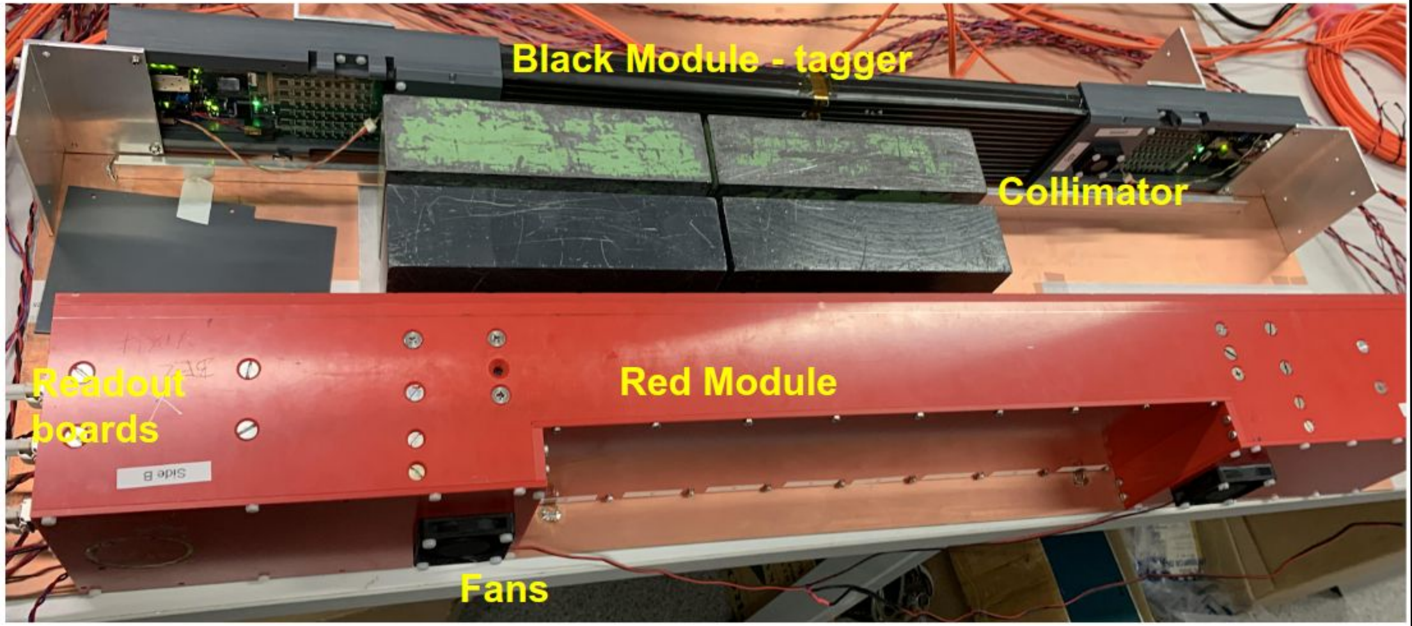
[1] P. Moskal, E. Ł. Stępień, PET Clinics 15, 439-452, (2020).
[2] P. Moskal, Sz. Niedźwiecki, et al., Nucl. Instr. Meth. A 764, 317 (2014).
[3] P. Moskal, O. Rundel, et al. Phys. Med. Biol. 61, 2025 (2016).
[4] J. Smyrski, P. Moskal, et al., BioAlgorithms and Med-Systems 10, 59 (2014).
[5] J. Smyrski, et al., Nucl. Instr. Meth. A 851, 39-42, (2017).
[6] P. Moskal, et al., Phys. Med. Biol. 66 175015, (2021).

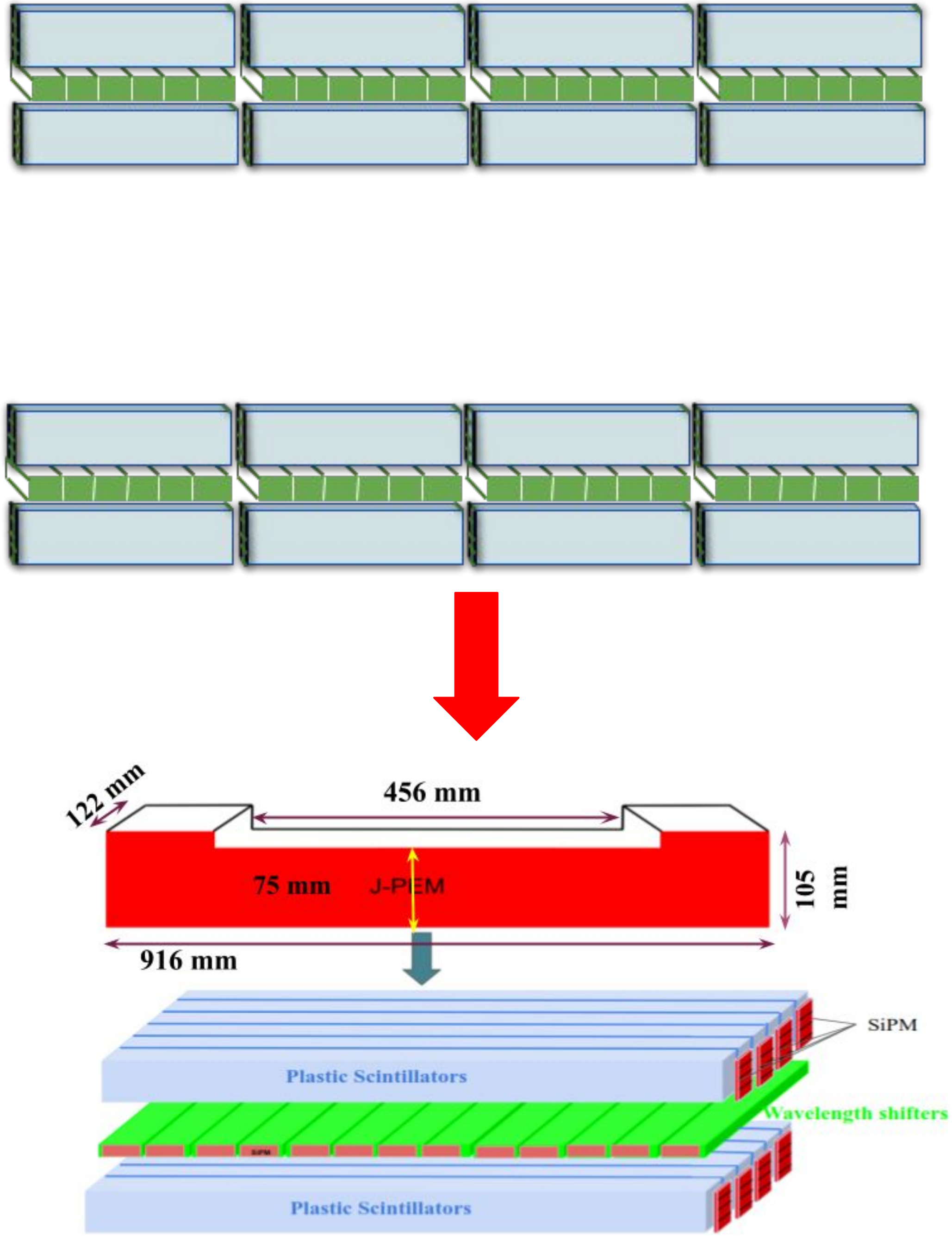
Measurement Details

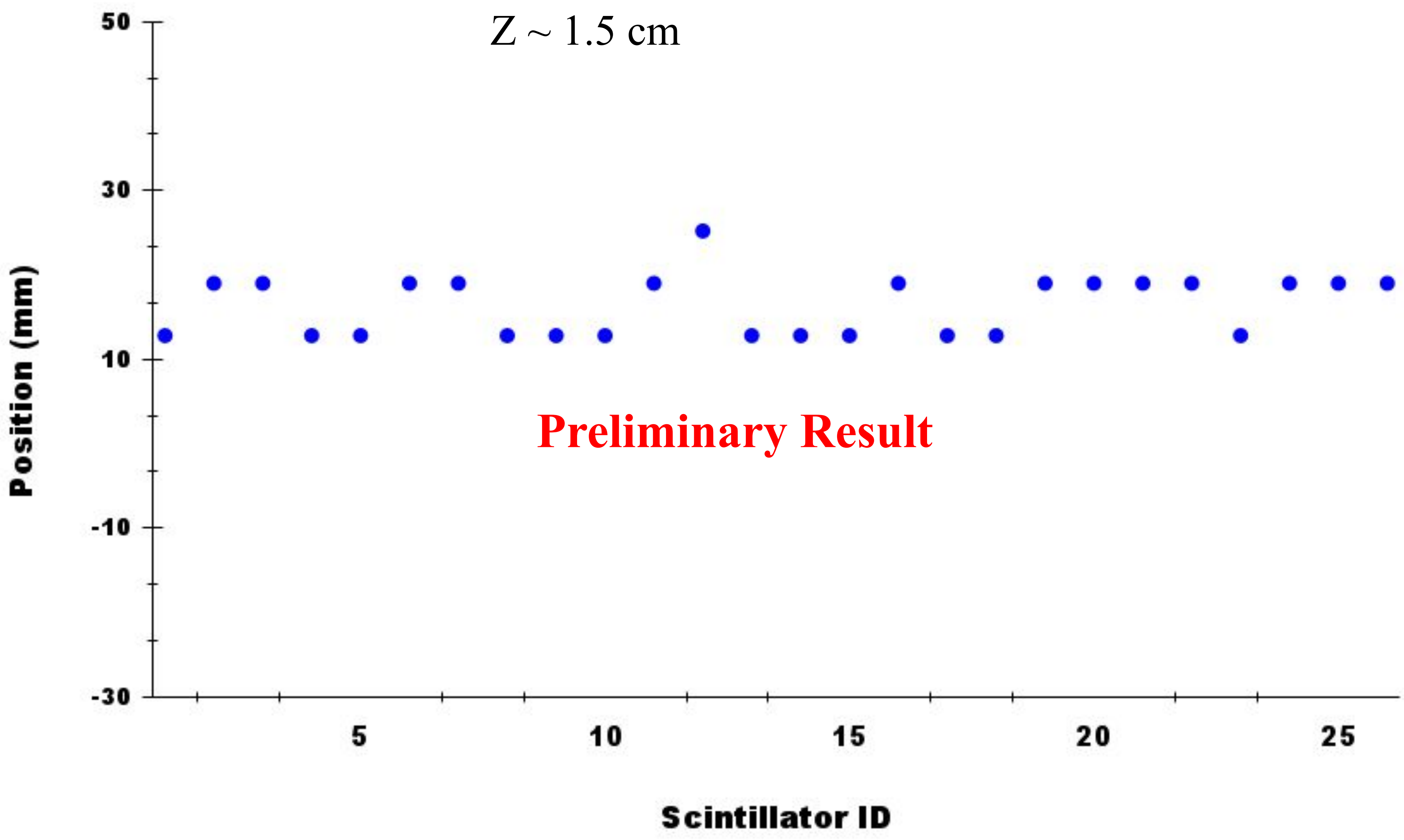
Measurement for a different set of thresholds and **new source (18.5 MBq)**.

- **Time of measurement - 10 mins**
- SiPM Voltage - 58.8 V
- **Slit width - 4 mm**
- Source - 10 cm shift from center to the left side of the module.

Threshold value - 40 mV







Z ~ 1.5 cm
50
30
10
-10
-30
Position (mm)
Preliminary Result
5
10
15
20
25
Scintillator ID