Nuclear instrument techniques to improve the diagnosis of breast cancer by using plastic scintillator and wavelength shifters

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Introduction

Breast cancer is the most leading cause of death among women in both developing and developed countries. Medical imaging plays an important role for breast cancer screening, for classifying and examining indistinct breast abnormalities, as well as for defining the extent of breast tumors. One of the most widespread modalities currently available is the Positron Emission Mammography (PEM) [1]. J-PET group aim is to design, construct and establish the characteristic performance of the Mammo-PET, based on a novel idea with plastic scintillators[2,6] and wavelength shifter (WLS) readout.

Experimental Details

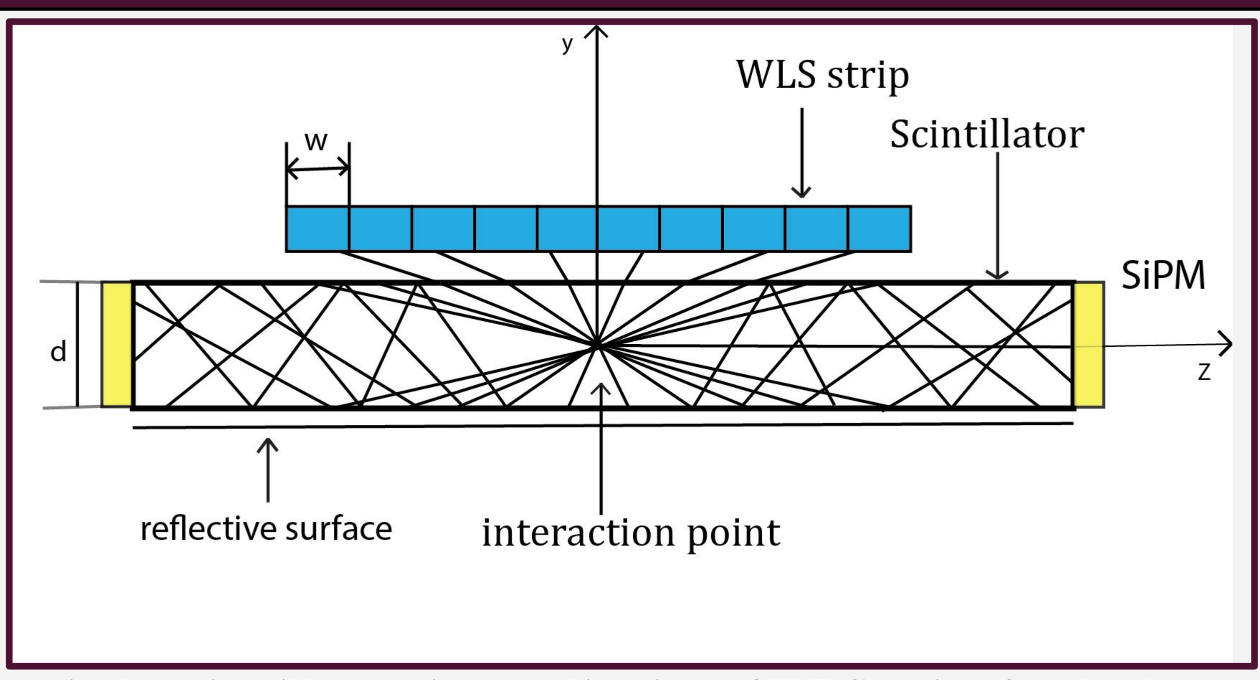

Fig.1.Schematic drawing illustrating application of WLS strips for the determination of the coordinates of the interaction point in a scintillator strip.

- ❖ Fig.1. An example of photon propagation inside the scintillator. The photon trajectories are indicated as straight lines from the geometrical center.[3]
- ❖ For emission angles larger than the critical angle, the emitted photons undergo total internal reflection from the walls of the scintillator strip and propagate towards the Silicon photomultipliers (SiPMs). Their trajectories are indicated with thin, black lines.
- ❖ For emission angles smaller than the critical angle, scintillation photons can escape the scintillator strip through a side wall and can be absorbed in the WLS strips. Trajectories of such photons are indicated as thick, blue lines and the WLS strips which absorb these photons are marked with blue color.
- ❖ Secondary photons emitted isotropically by the WLS strips propagate towards photomultipliers attached at their end.

Scintillator	WLS
BC-420	BC-482A
5X19X300mm³	3X5X100mm³
Wavelength of maximum emission - 391 nm	Wavelength of maximum emission - 494 nm

Table.1- Comparison between the properties of Scintillator(BC-420) and Wavelength shifter (BC-482A). This combination of both is used to determine the spatial resolution.

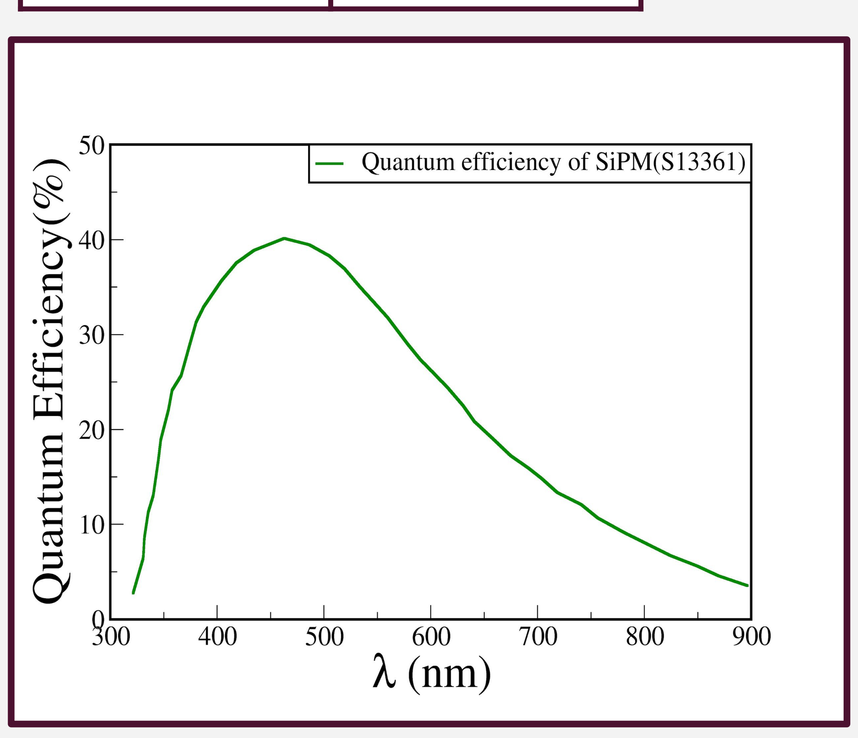

Fig.3.Quantum Efficiency of Silicon PhotoMultiplier(S13361).[4]

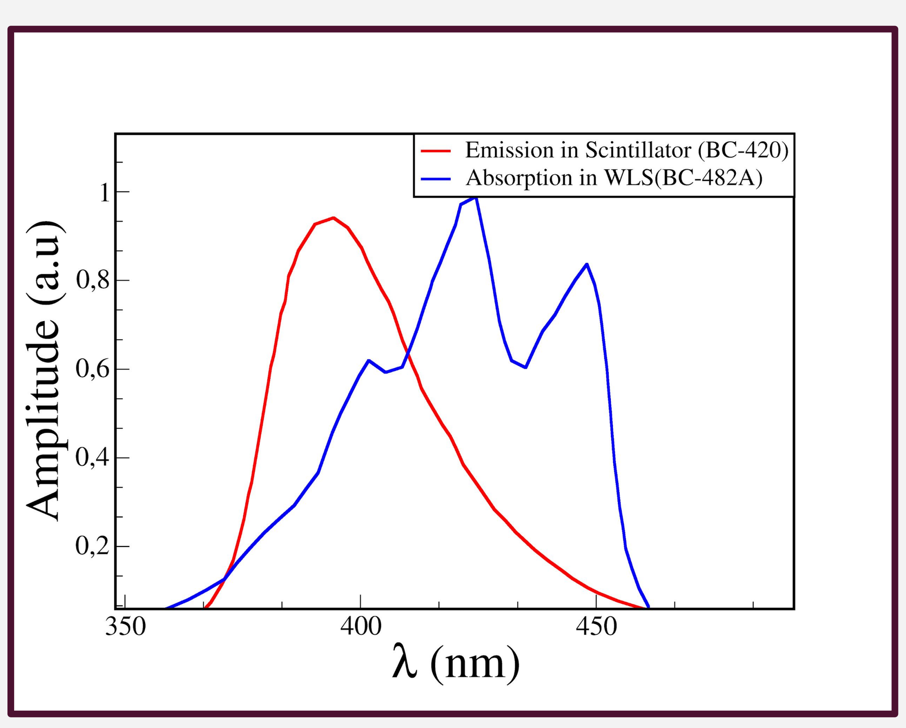

Fig. 2. Emission and absorption spectra for the exemplary plastic scintillator and wavelength shifter.

Results

- ❖ To determination of the position of the interaction point in a plastic scintillator we propose to use a set of parallel WLS strips which register scintillation photons escaping the scintillator (for emission angles smaller than the critical angle) [5].
- ❖ The axial coordinate of the interaction point along the scintillator bar can be determined on the basis of the amplitudes measured in individual WLS strips e.g. by the center of gravity method.
- ❖ It is expected, that with a width of the WLS strip of w = 5 mm the resolution of the z coordinate should be of about 5 mm [3] as shown in Fig.6.
- ❖ First prototype, consisting of 16 WLS and 1 scintillator, was already tested and showed promising results.

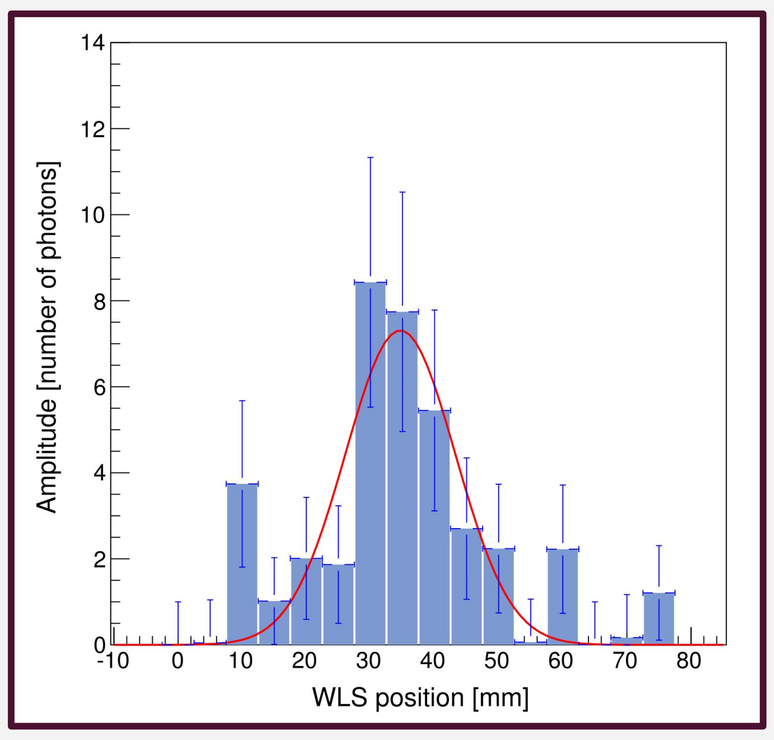

Fig. 5. Amplitudes measured Distributions of reconstructed

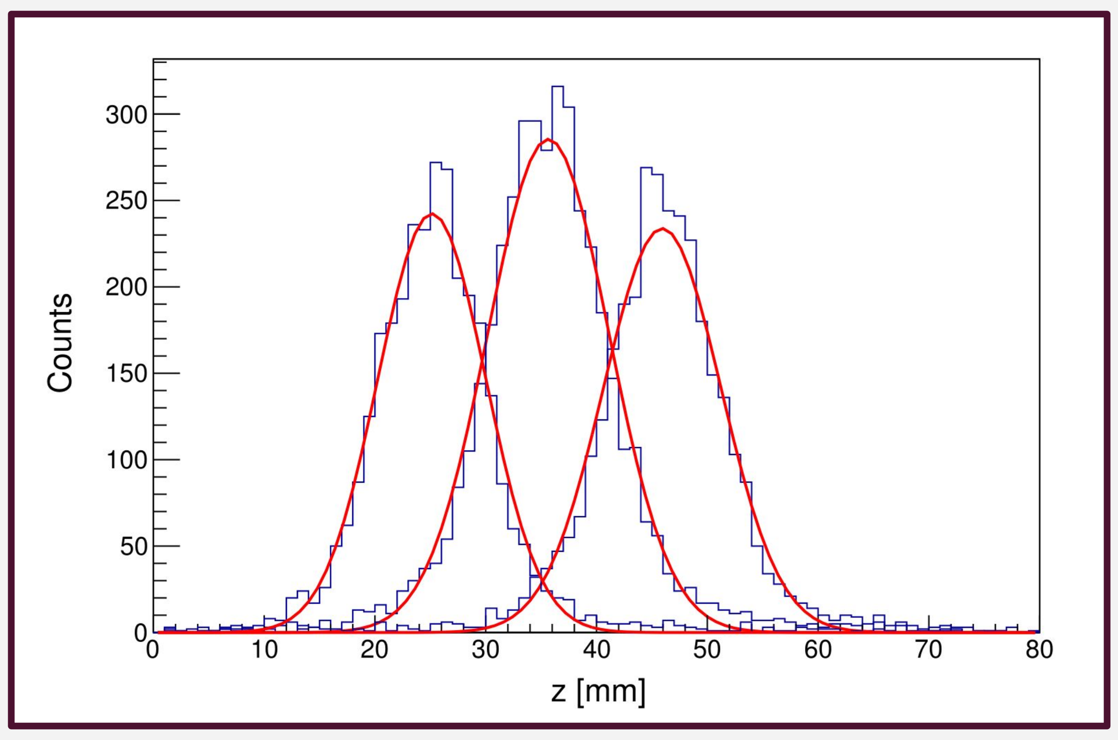

Fig.6. Distributions of reconstructed z–coordinates of the gamma quantum interaction for three different positions of the 22Na source.

Future Plan

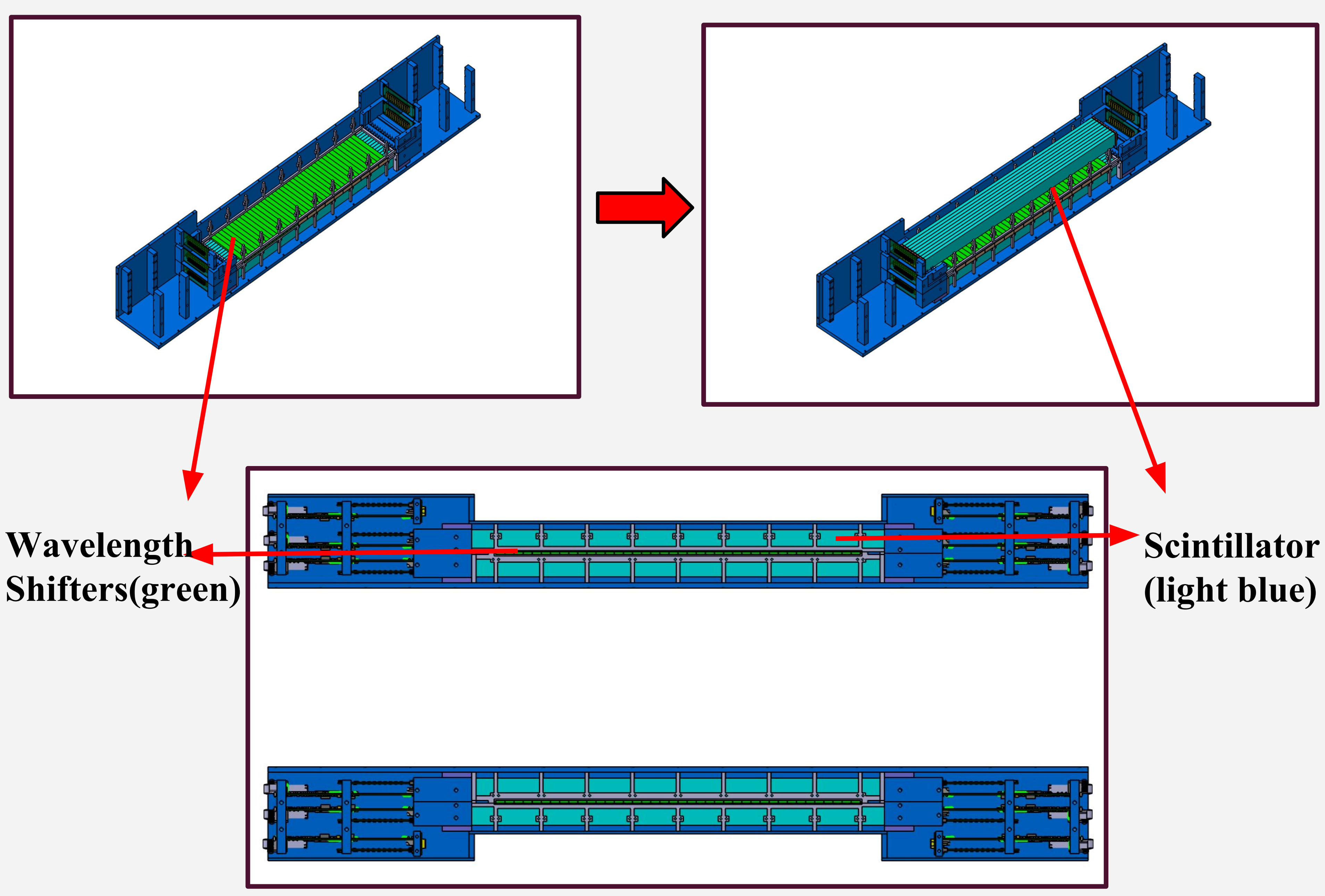

Fig.6. First Prototype of two modules.

Conclusion

Mammo-PET is a new instrumental technique based on PEM(positron emission Mammography), with better sensitivity and specificity. This improvement will be possible by the employment of plastic scintillators combined with WLS strips.

Referefences

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