Recent Progress in Instrumentation for PEM Imaging

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Breast imaging with nuclear medicine methods has been under investigation since the late 1980s when scintimammography was first introduced. Nuclear medicine techniques detecting the preferential uptake of a radiotracer in breast lesions, have the potential to provide functional information that complements conventional anatomical imaging techniques such as mammography and ultrasound[1].

The limitations of gamma cameras and SPECT for breast imaging include the relatively poor spatial resolution (10–15 mm) and reduced counting sensitivity[2]. While the spatial resolution of PET is superior to that of conventional gamma cameras, current clinical PET scanners only achieve 4–6 mm resolution. Many small, clinically relevant breast lesions are not detected with current whole body PET/CT systems. Small tumor size (<10 mm) and low tumor grade result is a significant fraction of false-negative FDG PET results[3].

Since 20 years researchers have exploited the potential of new, dedicated positron emission mammography instruments to improve the detection of small breast lesions[4]. The main advantage of a breast-dedicated machine over conventional PET scanners is substantially improved spatial resolution. While few commercial systems are presently available, the research community has developed numerous breast-specific PET systems with arrays of high density scintillating detectors coupled to PMTs or more recently, semiconductor photodiodes. The scintillators most commonly used include LSO, LYSO, LGSO and BGO. In one high-performance Positron Emission Mammography (PEM) scanner a spatial resolution of 1.4 mm has been achieved[5]. Two main types of designs were pursued: either two flat detectors placed on opposite sides of the breast, or a small ring of detectors placed below the patient in prone position[6]. By imaging only the breast rather than the entire chest, attenuation and scatter image corrections are simple or may not even be required.

The recent introduction of high performance silicon photomultipliers (SiPM) has the potential to bring decisive improvements in PET scanning. Relative to traditional photomultipliers, SiPMs are compact, have fine segmentation, are compatible with MR imaging, and, last but not least, allow extremely good PET coincidence timing (150-200 ps FWHM)[7]. This last feature allows increasing the equivalent sensitivity by a significant factor (3 to 10 dependent on breast size), and consequently to reduce the radiotracer dose by the same factor.

References:

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