Resolution Studies of a New Small Animal PET System based on Scintillating Fibers

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Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET) are widely used in the clinic and in the laboratory. The technique detects radiolabeled agents quantitatively at the picomolar level and detects normal and disturbed biochemical and physiological functions noninvasively and quantitatively that are not available otherwise. PET in animal models is a powerful technique capable of answering basic and applied questions in biology and pharmacology.

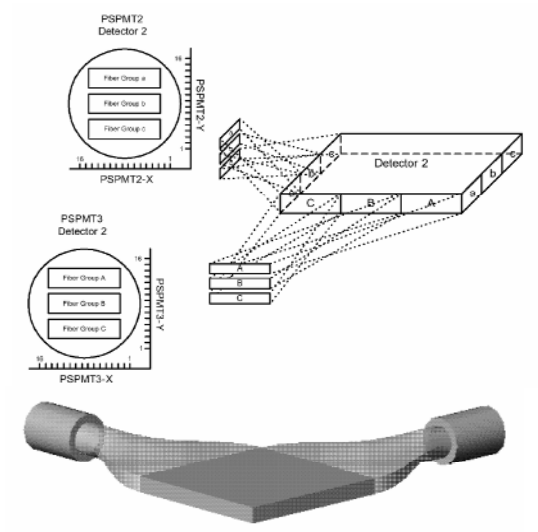

Figure 1: Scheme of PSPMT-to-Fiber Detector Layout.

The newly developed system [1,2,3] comprises two plastic fiber scintillator detectors, the position sensitive photo multiplier tube (PSPMT) light sensors, PET coincidence trigger electronics, and a custom-built FADC crate to digitize detector signals. The current Data Acquisition (DAQ) system is based on a multistandard platform: a custom back plane for the Analog-to-Digital Convertor (ADC) modules and a PXI (the Compact PCI standard from National Instruments) enclosure for the data readout from the ADCs. Two interface modules (PXI-6508 for slow control, and PXI-6533 for the fast data transfer) are included in this enclosure. The current data transfer rate is about 6 MB/s (~40 K events per second), with the possibility to attain a final data transfer rate of 40 MB/s. Small animal scans usually are performed with activities of 1-3 mCi and take from 20 to 40 minutes. The detectors were fabricated using BCF-10 (Bicron Corp, Newbury, Ohio) scintillating plastic fibers. The fiber core is polystyrene $(C_8 H_8)_n$ doped with butyl-PBD and dPOPOP. The fibers are clad in a non-scintillating Lucite cladding. Generally, the scintillation mechanism is via excitation of π-electrons in the butyl-PBD benzene ring. These ~365 nm photons penetrate through a plastic scintillator by a distance of ~1 mm and produce a so-called X-Y "conferencing" effect firing the neighboring fibers due to wave-shifting mechanism with the dPOPOP to ~420 nm. This wavelength provides high fiber transparency and is also more compatible with the optimal spectral response of standard photo multiplier cathodes. The photo electron fraction is small and Compton scatter interactions dominate in the photon energy distribution in a plastic scintillator at 511 keV. The scatter electrons give up their energy well within a 1 mm range.

The detectors consist of an epoxied stack of 28 layers each containing 135 fibers. The criss-crossed overlap region forms a 13.5x13.5x2.8 cm^3 detector volume. Fig. 1 shows schematics of the PSPMT-to-detector fiber layout.

As local resolution of the imaging also depends on the mean and respectively, the maximum kinetic energy of the positron emitted, in this study, the spatial resolution of the scanner for various positron emitting isotopes [4] was studied. Point sources of 1mm diameter were prepared, measured in the center of the field of view and FWHM values were calculated. Isotopes used were: ^{22}Na, ^{18}F, ^{74}As, ^{124}I and ^{72}As.

The results are illustrated in Fig. 2, showing a linear dependency between mean positron energy and spatial resolution of the scanner system within reasonable errors.

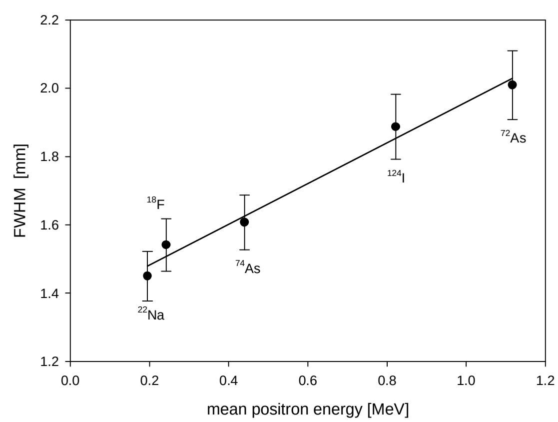

Figure 2: Spatial resolution for different positron emitting isotopes versus their mean positron energy. Measurements were done at the Small Animal PET of the UTSW Medical Center at Dallas using equal-sized point sources, Ø = 1 mm.

References:

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