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LEAST-SQUARES OPTIMIZATION OF RECONSTRUCTION FILTERS FOR HIGH RESOLUTION PET BRAIN IMAGING.

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We have investigated the ability of various reconstruction filters in high resolution PET to image quantitatively tracers that have selective accumulation in the gray matter. For this work, we imaged the Hoffman brain phantom with the Donner 600-Crystal Positron Tomograph. This phantom was designed to accurately simulate the human brain by depicting the shape of the ventricles and the relative uptake of F-18 fluorodeoxyglucose in gray and white matter. The tomograph has a circular point spread function (PSF) with a full width at half maximum (fwhm) of 2.6 mm at the center of the field.

Images of the F-18 distribution were reconstructed with various numbers of events and filters, the root-mean square (rms) deviation between the emission image and a model was computed, and these rms deviations were then used to quantitatively determine the optimal filter for a given number of events. To perform the rms calculation, a digital model of the Hoffman phantom was produced by imaging the air-filled phantom with 3,000 million transmission events and assigning each pixel to one of three regions: air, white, or gray. A gray:white:air ratio of 3.2:1:0 was assigned based on region of interest measurements of high statistics F-18 emission images, and the overall normalization between emission image and model was computed using the total number of counts in the reconstructed images.

The images were filtered with a Butterworth filter having a rolloff of 90% at a lower frequency A and 10% at an upper frequency B. With 1 million events, the best image was achieved with A = 0.7 and B = 2 cycles/cm, while with 55 million events, the best image was achieved with A = 2 and B = 3 cycles/cm.. When these filters were used to obtain the point spread function, the fwhm's are 5.0 and 3.5 mm at the center respectively. We conclude that 1 million events from F-18 FDG are sufficient to image the brain with 5 mm resolution.

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Number of events	Pass (90%) frequency (cycles/cm)	Stop (10%) frequency (cycles/cm)	fwhm (mm)	average deviation (%)	rms deviation (%)	average deviation (%)	rms deviation (%)
55×10^6	0.7	1.0	8.5				
	0.5	1.0	8.7				
	0.3	1.0	8.0				
	1.0	1.5	5.9				
	0.7	1.5	6.2				
	0.5	1.5	6.2				
	0.3	1.5	?				
	1.5	2.0	4.5				
	1.0	2.0	5.0				
	0.7	2.0	5.1				
	1.0	3.0	4.0				
	1.5	3.0	3.7				
	2.0	3.0	3.5				
	3.5	5.0	?				
5×10^6							
1×10^6							