Supplemental Materials

Transmission scanning protocols

Transmission scanning in the HRRT is controlled by the speed of the ^{137}Cs source in two directions: the axial direction and azimuthal direction. A typical transmission scanning time of the HRRT was approximately six minutes with 50% of the relative axial speed and two steps of the azimuthal crystal.

CT imaging was performed using a typical protocol for human brain scanning. The typical protocol for a CT scan of the human brain included a rotation speed of 0.8 seconds per rotation and 130 kVp of energy with 132 mA of tube current. Obtained CT images had a voxel size of 0.49 × 0.49 × 1.5 (mm^3) with a 512 × 512 × 186 matrix.

Emission scanning protocols

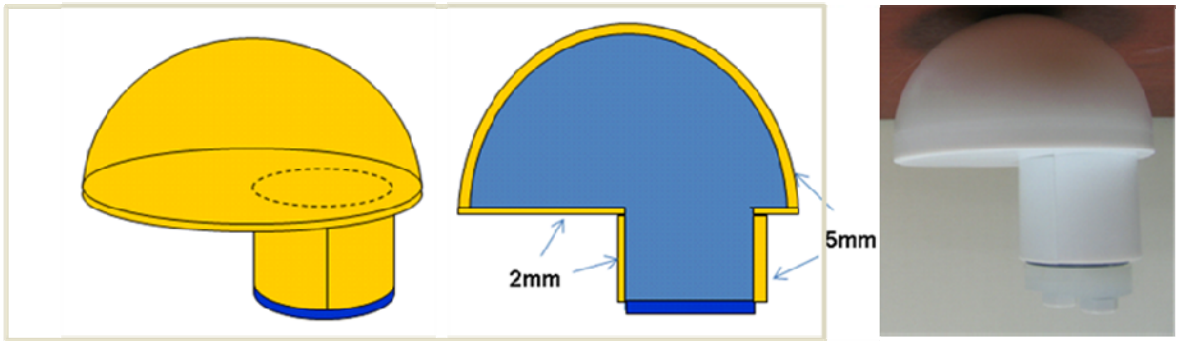
The NRI phantom was filled with a mixture of 18.5 MBq ^{18}F-fluorodeoxyglucose (FDG) and 800 ml distilled water. After positioning and fixing at the center of the FOV of the HRRT, an emission scan was performed for 60 minutes.

For human subjects, an FDG emission scan was acquired either with the HRRT or with the PET/CT scanner. Each image was obtained with identical scanning protocols: 30 minutes for the uptake of 185 MBq FDG via intravenous injection and 30 minutes for scanning.

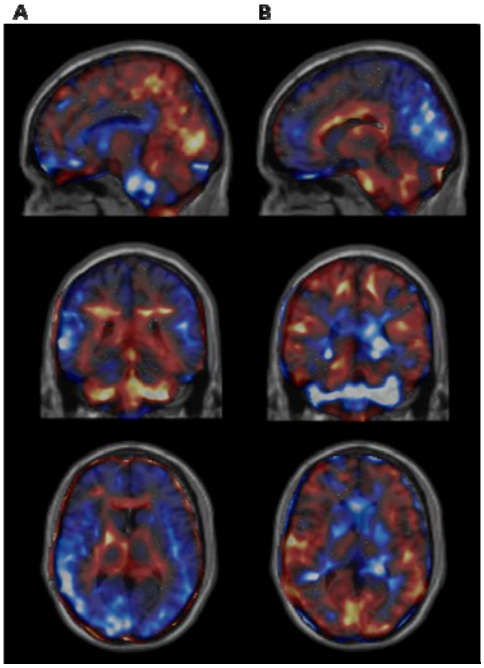
Scaling of the μ-map obtained by ^{137}Cs transmission data

HRRT was equipped with 137Cs point source emitting single photon with 662keV. This different energy of the transmission sources from the PET radio-ligands caused the biased attenuation coefficients in the reconstructed μ–map. In order to correct this problem, HRRT system adopted the automatic scaling method in the MAP-TR algorithm with smoothness and intensity priors. Intensity prior of each compartment specifies mean, variance, boundaries of a Gaussian function. Sum of these Gaussian functions approximates the histogram of the μ–map at 511keV. Ten iterations of MAP-TR algorithm were used. The first five iterations of MAP-TR algorithm were performed without using the segmentation priors. The scaling factor was obtained from the first five iterations image by the assumption that the most abundant attenuation coefficient from the histogram of the μ–map was the water peak. This scaling factor was used to convert the intensity priors from 511keV to 662keV and then the remained iterations were continuously performed with the scaled intensity priors. Finally, the scaling factor was

used to convert the reconstructed μ–map from 662 to 511keV (Private communications with Dr. Merence Sibomana at Rigshopitalet, Copenhagen University Hospital, Denmark)



Supplemental FIGURE 1. Diagram and picture of the new attenuation phantom. The inner shell can contain 780 ml of water and is made of polyethylene. The upper part represents the cerebral cortex in the shape of a hemisphere, and the bottom is connected to a small cylinder that represents the cerebellum and the brainstem. The thinner shell corresponds to the undetected parts in the ^{137}Cs transmission scan.



Supplemental FIGURE 2. Comparison of the positive and negative bias pattern between the MAP-TR_{def} vs. CT-TR. Column A shows the difference of the HRRT image using the MAP-TR_{def} algorithm from PET/CT and the column B shows the difference of the HRRT image using the CT-TR algorithm derived from the MAP-TR_{def} algorithm. It is worthy of note that the bias pattern of MAP-TR_{def} compared to the PET/CT was inversely close to the bias pattern of CT-TR (Right) compared to the MAP-TR_{def}.

Supplemental Table 1. Comparison of the HRRT PET and PET/CT

Specifications	HRRT PET	PET/CT
Number of heads or buckets	8	12
Number of rings	1	3
Number of detector modules per head or bucket	9X13	4X4
Number of crystals per detector module	8x8	13x13
Dimension of the crystal (WXHXD)	$2.3x2.3x10mm^3$ X2 (Double Layer)	$4x4x20mm^3$
Material of the scintillator	LSO/LYSO	LSO
FOV	Transaxial : 312mm Axial : 252mm	Transaxial : 585mm Axial : 162mm
Transmission source	^{137}Cs point source (740MBq)	CT (X-ray)

Supplemental Table 2. Used reconstruction algorithm for transmission data

Reconstruction Algorithms		Segmentation or Prior Parameters Set			
		Air	None-bone tissues		Bone
			Cavity	Soft Tissue	
NEC-TR and segmentation	Threshold	$\mu < 0.0085$	$0.0085 \le \mu \le 0.12$		$\mu > 0.12$
	Mean	$\mu = 0.0$	$\mu = 0.096$		$\mu = 0.14$
MAP-TR_{def}	Threshold	$\mu < 0.03$	$0.03 \le \mu \le 0.07$	$0.07 \le \mu \le 0.105$	$\mu > 0.105$
	Mean (SD)	$\mu = 0.0$ (0.005)	$\mu = 0.03$ (10)	$\mu = 0.096$ (0.02)	$\mu = 0.110$ (10)
MAP-TR_{adj-b}	Threshold	$\mu < 0.03$	$0.03 \le \mu \le 0.07$	$0.07 \le \mu \le 0.118$	$\mu > 0.118$
	Mean (SD)	$\mu = 0.0$ (0.005)	$\mu = 0.03$ (10)	$\mu = 0.096$ (0.02)	$\mu = 0.120$ (10)
MAP-TR_{adj-t}	Threshold	$\mu < 0.03$	$0.03 \le \mu \le 0.07$	$0.07 \le \mu \le 0.105$	$\mu > 0.105$
	Mean (SD)	$\mu = 0.0$ (0.005)	$\mu = 0.03$ (10)	$\mu = 0.0994$ (0.02)	$\mu = 0.110$ (10)

*It is assumed that each prior has a non-overlapping Gaussian distribution of mean and standard-deviation.