

3T Head Neck Coil for Simultaneous MR-PET Imaging

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Introduction: MR-PET combines the advantages of MRI's morphological imaging with excellent soft tissue contrast and PET's functional molecular imaging. Vendors offer sequential scanners that have separate gantries for PET and MR in the same room. Integrated MR-PET scanners are also available and offer several advantages over sequential scanners such as reduction in overall scan time and elimination of patient repositioning. Images acquired from integrated scanners are easily registered and analyzed. However the challenges of an integrated MR-PET system are different from a sequential scanner. In MR imaging, phased array surface coils are positioned close to the patient for achieving higher SNR. In an integrated MR-PET system, these coils are directly in the PET field of view and attenuate positrons resulting in artifacts or poor quality PET images. This is especially a concern for whole body imaging where the patient is setup once and a full body scan is conducted. Hence having low PET attenuation is critical to good quality PET images during simultaneous MR-PET acquisition. Surface coils have never been designed to incorporate this requirement. Previous attempts have been limited to evaluating the effects of RF coils on PET images or using attenuation maps to perform correction [1-3]. This paper presents a head neck coil at 3T designed specifically to be transparent to PET positrons. MR SNR performance was compared with the industry benchmark 8 HR Brain coil. Improvement in PET transparency was measured by comparing the sensitivity loss to G.E.'s 3T GEM Head neck coil which was designed for MR only imaging. MR performance was within 9.5 percent whereas sensitivity loss improvement was an average of 41.9% over the entire coil.

Methods: The first of several key strategies applied during the design was to move majority of the components outside the PET FOV, on the superior side of the head. Secondly, PET attenuation was also improved by reducing the thickness of the coil former. Thirdly, every module inside the coil was redesigned and tested to be PET transparent. The twenty three element head neck coil was constructed using strips cut from 0.125 inches wide annealed copper (thickness=0.25mm). G.E. feedboards were used for receiving signal from the coil elements. Adjacent elements were isolated by overlap whereas next nearest and further elements were isolated by using low input impedance preamplifiers. Each element was tuned to 127.73MHz and matched to 50 ohms. Bench measurements were collected using an RF network analyzer 8712ES (Agilent Technologies). Loaded Q was measured by loading the coil with a Head and Neck phantom with an internal bone structure filled with 3.3 g/L NiCl₂ and 2.4g/L NaCl manufactured by Dielectric Corp. Polycarbonate material was used in a Stratasys FDM Machine to



Fig.2: Axial Noise Images (Top) & Signal Images (Middle & Bottom) of a spherical phantom taken from 8 Channel Brain Coil (Left) and MR-PET HNU Coil (Right)

build thin formers and covers for the coil. The thickness of these formers was chosen per estimates for strength/rigidity and PET transparency. MR performance was measured by comparing head SNR to the industry standard 8HR Brain coil. Axial images of a 10cm radius spherical phantom filled with non-loading solution were acquired from both coils on a 3T/70 cm G.E. 750w scanner. (Spin echo, TR/TE=500/20msec, matrix=256x256, FOV=45cm, st=5mm, N_{av}=1). SNR was computed by acquiring separate signal and noise images and dividing the signal mean by the noise standard deviation over circular ROIs. PET performance improvements were measured by calculating sensitivity loss for a 10 min period over three 15cm regions that covered the entire coil length in the S-I direction. Sensitivity loss is defined as the difference between coincidences counts recorded with and without the RF coil as a percentage of the counts recorded without the coil. Scans were acquired with GE's Discovery PET/CT 600 scanner. A cylindrical phantom of 21.2cm diameter and 28.98cm height filled with ⁶⁸Ge was used to calculate the average sensitivity loss over the each bed.

Results: Figure 1 shows the division of each coil into three adjacent beds measuring 15cm each. Table 1 shows sensitivity loss of the coil as compared to G.E.'s GEM Head neck unit. We observed a 41.84%, 43.49% and 40.51% improvement in sensitivity loss in each of the three beds respectively. Fig 2 shows the signal and noise images acquired and measurement ROIs for the non-loading spherical head phantom for the 8 HR Brain and the MR-PET Head neck coil. Table 2 shows that for the MR-PET coil over a large Ø= 15cm circular ROI, the signal measured was 6.1% higher; the noise standard deviation was 17% higher; making the SNR within 9.5% of the brain coil. More importantly for brain imaging, in a small Ø=5.2cm ROI close to center of the phantom, the signal measured was 7.1% higher; making the SNR within 8.6% of the brain coil.

Conclusions: Given the significant improvement in PET transparency without compromising MR performance, this coil is ideally suited for simultaneous MR-PET head neck imaging. The results show that reconsidering coil design for PET transparency can yield considerable benefits. These developments can improve MR-PET image quality and reduce artifacts induced by RF coils. Future work will include scanning phantoms and volunteers to quantifying these improvements.

References: [1] Herrick et al; Proc ISMRM 2011;3801 [2] Bindseil et al; Proc ISMRM 2012;146 [3] G. Delso et al., Phys. Med. Biol., 5, pg. 4361, 2010

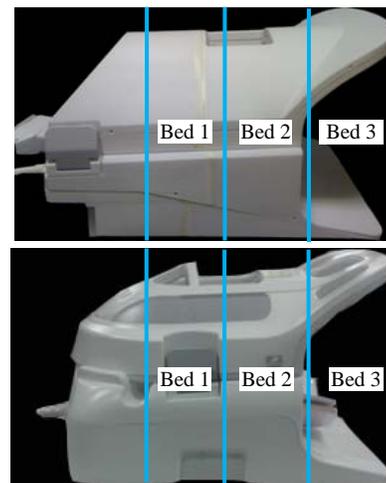


Fig. 1: Twenty three element MR-PET head neck coil (Top) and GEM head neck coil (Bottom) shown divided into 3 beds for measuring PET performance.

Bed No.	GEM HNU Sensitivity Loss %	MR-PET HNU Sensitivity Loss %
Bed 1	21.41	12.45
Bed 2	21.61	12.21
Bed 3	7.43	4.42

Table 1: Sensitivity loss measurements for MR-PET head neck coil and GEM head neck coil.

	8HR Brain Coil	GE's MR-PET HNU
Noise SD	9.8	11.5
Signal Mean (Large ROI)	9576.3	10167.6
Signal Mean (Small ROI)	7565.7	8103.9
SNR (Large ROI)	978.5	880.5
SNR (Small ROI)	771.94	717.65

Table 2: Relative Signal, Noise and SNR of coils