# An MR compatible fluorescence tomography system

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**Introduction :** Multi-modality imaging is becoming a trend in developing new generation *in vivo* imaging techniques for diagnosis [1]. MRI is a high resolution imaging modality, while fluorescence tomography (FT) is becoming an important molecular imaging tool despite of its low spatial resolution [2]. In FT, there are two parameters that can be spatially resolved, namely fluorophore concentration and lifetime [3]. It has been shown that the anatomical a priori information provided by MRI can be used to improve the quantitative accuracy of FT. However, most of the current FT system designs utilize CCD as the detector, which is incompatible with MRI [2]. To be able to build a hybrid MRI-FDOT system, it requires new hardware compatible with each other. In this study, we investigated the feasibility of a photo-multiplier tube (PMT) based detection system that uses fiber bundles to collect light from the medium under investigation. There are several advantages of using the PMT together with the fiber bundles. First, the PMT has a very high sensitivity due to its intrinsic high gain. Second, due to its fast response time, the PMT is ideal for time dependent measurements, which are required to recover the fluorescence lifetime parameter. Finally, the fiber bundles improve the capability of the FT system to detect very low level emission signals from the fluorophores located deep in thick tissues such as breast due to their large aperture. In this feasibility study, we demonstrated that the fluorescence parameters can be well recovered for a small object (6 mm) embedded in a breast-sized phantom (80 mm) when the fiber bundle detectors are utilized. The performance of a 1.1-mm core diameter single fiber was also compared to demonstrate that our fiber bundle based design is more superior for human imaging application in the future.

**Method :** We choose a head-on PMT as the photon detector. The output signal was measured by a network analyzer. The phantoms were prepared using agarose powder. The Intralipid and Indian ink were added as optical scatterer and absorber media, respectively. Two different kinds of near infrared fluorophores were used in the experiment, ICG and DTTCI. Both of these fluorophores could be excited by the 785 nm laser and the emission light could be collected using an 830 nm band pass filters due to their similar excitation and emission spectra. In this phantom study, we constructed an 80 mm diameter breast sized phantom. The phantom had two 6 mm diameter holes located at 20 mm away from the center of the phantom, and 135 degrees apart from each other. The background optical properties were $\mu_{ax} = 0.008$ mm$^{-1}$, $\mu_{am} = 0.007$ mm$^{-1}$ and $\mu_{s'x,m} = 0.95$ mm$^{-1}$. Two cases were tested using ICG and DTTCI as the fluorescence inclusion, respectively. The ICG and DTTCI concentrations in the inclusion were 67 nM and 202 nM, and the lifetimes of the ICG and DTTCI were 0.56 ns and 1.18 ns, respectively. Phase and amplitude measurements were acquired with both the 1.1 mm single fiber and 6mm fiber bundles.

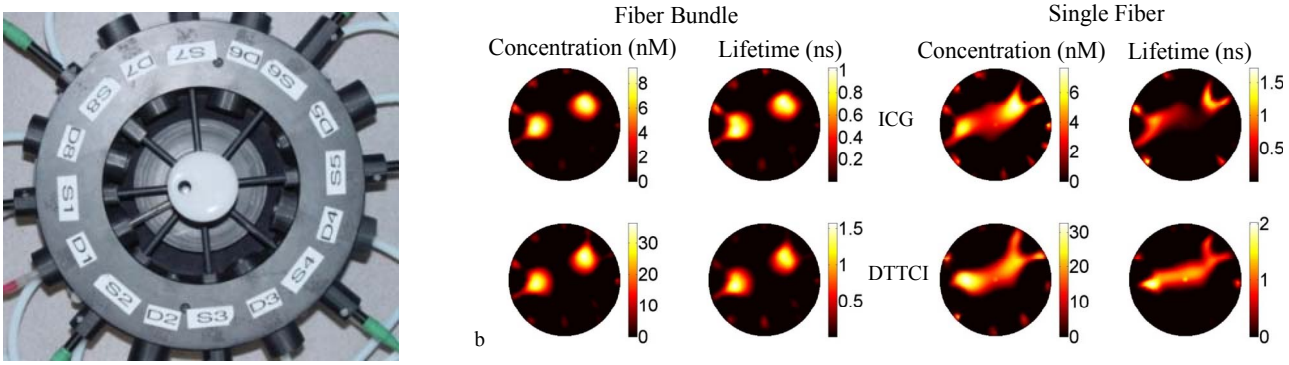


Fig. 1 (a) The MRI-compatible interface. (b) FT reconstruction results for phantom study 1. The first and second columns are the reconstructed fluorophore concentration and lifetime from the fiber bundle detector measurement. Meanwhile, the reconstructed fluorophore concentration and lifetime maps from the single fiber detector are presented in the third and forth columns.

**Results :** As shown in the first and second columns in Figure 1, both the fluorescence concentration and lifetime can be reconstructed from the fiber bundle detector measurement. On the other hand, as a result of the low quality of the measurements taken by the single fiber detector measurements, the recovered fluorophore concentration images show more artifacts, and the fluorophore lifetime cannot be recovered, as shown in the third and fourth columns of Figure 1.

**Discussion :** In this study, we showed that an MRI-compatible PMT based detection system together with fiber bundles can retrieve both the fluorophore concentration and lifetime maps even in such a large medium. On the other hand, the single fiber used with the very same detection system did not allow reconstruction of accurate fluorophore lifetime maps due to low signal levels. The PMT is able to measure time-dependent measurement with high sensitivity. Currently, we are integrating this FT system with a 4T MRI to develop a true multi-modality system.

**References :** [1]. Frangioni, J.V. J Clin Oncol. 26:24 (2008) [2]. Ntziachristos, V. *Annu. Rev. Biomed. Eng.* **8**, 1-33 (2006). [3]. Patwardhan, S., Bloch, S., Achilefu, S. & Culver, J. *Optics Express* **13**, 2564-2577 (April 4, 2005).

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