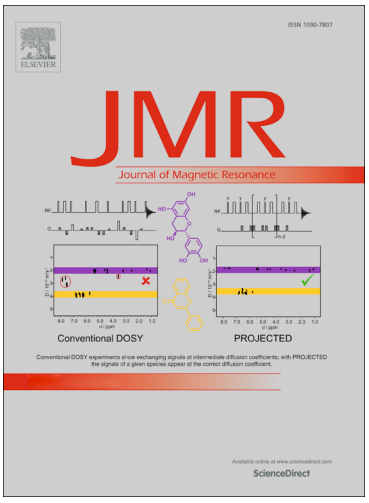
Accepted Manuscript



Visualizing the detection area of a unilateral NMR sensor using deconvolution and back-projection

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PII: S1090-7807(18)30232-5
DOI: https://doi.org/10.1016/j.jmr.2018.09.007
Reference: YJMRE 6369

To appear in: *Journal of Magnetic Resonance*

Received Date: 10 August 2018
Revised Date: 18 September 2018
Accepted Date: 19 September 2018

Please cite this article as: T. Überrück, C. Rehorn, R. Höhner, B. Blümich, Visualizing the detection area of a unilateral NMR sensor using deconvolution and back-projection, *Journal of Magnetic Resonance* (2018), doi: https://doi.org/10.1016/j.jmr.2018.09.007

Visualizing the detection area of a unilateral NMR sensor using deconvolution and back-projection.

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Abstract

Understanding the detection volume of a unilateral NMR sensor is crucial to interpret acquired data appropriately. Whereas this is easily done in the sensor's axial dimension by running a depth profile on a well-defined sample, the lateral dimension is commonly characterized with very small samples, where each position along a regular grid is scanned individually, typically resulting in measurement times of several days and a resolution that is limited to the dimensions of the sample. Here we apply two mathematical procedures known from image processing that employ samples larger than the pixel size to characterize the lateral detection area. One procedure uses deconvolution algorithms to account for blurring effects caused by a larger sample while the other utilizes back-projection of radial field profiles. Both approaches are demonstrated with a Profile MOUSE® (PM5). They yield field maps in good agreement with those acquired with pixel-size test samples but save about one order of magnitude in scanning time.

1. Introduction

Since unilateral sensors, such as the NMR MOUSE® [1] became commercially available, unilateral NMR has received growing interest in various fields of research such as cultural heritage [2], [3], polymer science [4]–[6], and medicine [7]. Several unilateral sensor designs are published and the complexity of the magnet arrays has been steadily evolving from its first, simplistic u-shape design with just two magnets [8] to unilateral Halbach magnet arrays with dozens of small magnets [9]. The most sophisticated design incorporated small shim magnets in the gaps between four main magnets and enabled to resolve the ^{1}H chemical shift in the ppm regime [10], [11]. The construction and design of unilateral sensors have been summarized in the literature that the interested reader is referred to [12], [13]. The commercialized and most commonly used type of sensor for the previously mentioned applications is the Profile NMR MOUSE® (Figure 1a) [14]. A well-defined gradient of magnitude similar to gradients used in NMR imaging is orientated perpendicular to the magnet surface, from here on defined as *y*-direction, and allows the measurement of thin sample slices in the micrometer range as all employed radiofrequency (rf) pulses are selective to a narrow slice.