# Design of an Anatomically and Physiologically Realistic Prostate Phantom

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## Introduction

Magnetic resonance spectroscopy (MRS) in the prostate is a promising tool for the non-invasive detection of tumours. It might even emerge as the first clinical routine application of MRS. However, only few sites perform MRS measurements on a regular basis despite the implementation into the GE product software. A main reason for this is the extraordinary difficulty of this exam. The male prostate is located in a region with an inhomogeneous susceptibility, leading to hampered shimming and thus broad line-widths. The prostate is surrounded by fat, which has to be suppressed additionally to volume localisation in order to obtain quantifiable spectra. The planning of a spectroscopy exam is therefore tedious and requires highly trained personnel. Prostate MRS is commonly performed with endo-rectal coils, which forbids extensive training and tests on healthy volunteers. A dedicated training and testing phantom might obviate this dilemma. Focus of existing prostate phantoms is mainly on pure metabolite solutions, although the outer fat layer is included some designs [1,2,3]. Objectives of this work were the creation of an anatomically and physiologically realistic prostate phantom.

## Methods and Materials

The phantom was designed to closely resemble the anatomy of the prostate including the surrounding fat layer and the rectum (Fig. 1). The shape of the inner compartment is approximately ovoid with a flattened bottom and has a volume of ≈90 ml. Its distance is towards the rectum is adjustable. The diameter of the rectum is 4 cm. An oil compartment surrounds both the inner compartment and the rectum. Everything is placed inside a water tank (diameter 38 cm; length 60 cm; total volume ≈70 l) to mimic the load of the lower abdomen. The imaging resolution can be assessed in all three spatial dimensions by "resolution boards", which are Plexiglas plates with bores in various sizes. The whole phantom is duplicated to allow investigation of both normal and abnormal concentrations in one experiment without repositioning the phantom. An endo-rectal coil can be inserted through the rectum.

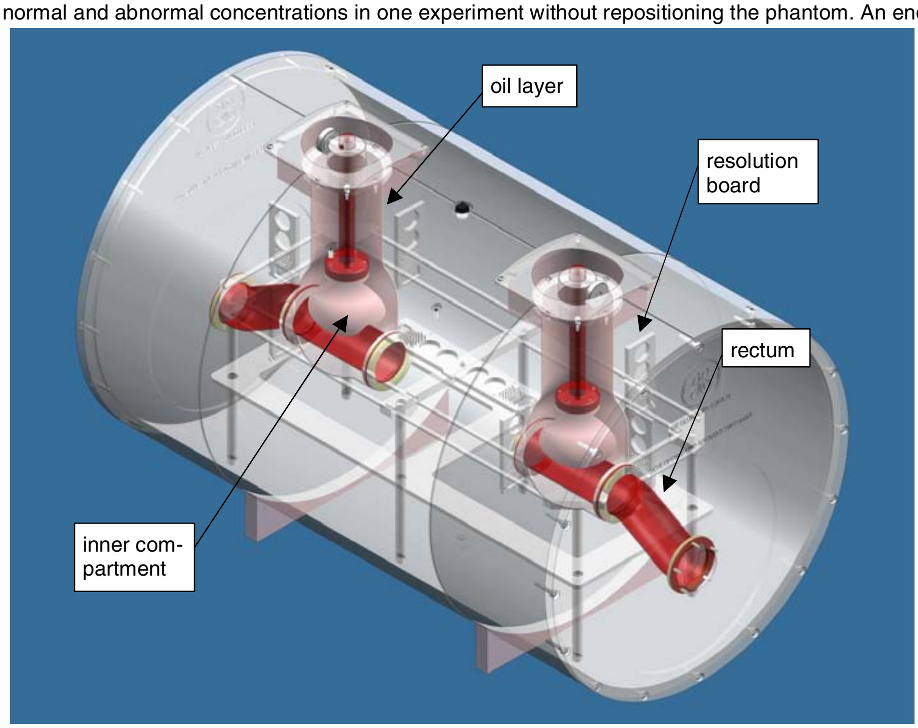


**Fig. 1:** Sketch of the prostate phantom. The anatomy of the prostate is closely resembled by this design.

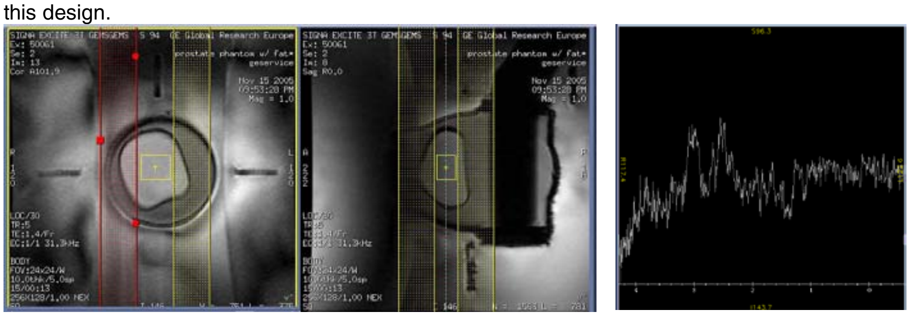

**Fig. 2:** Scout images for planning the spectroscopy voxel (left) and the acquired spectrum (right).

The performance of both the MRI and MRS measurements can be assessed by several features especially designed for higher field strengths (i.e., $B_0 \geq$ 3T). The bore size of the resolution board is going down to sub-millimetre size for evaluating high-resolution scans.

The inner compartment is filled with a metabolite solution composed of 90 mM citrate, 18 mM spermine, 9 mM choline, 12 mM creatine, 61 mM KCl, 18 mM $CaCl_2$, 15 mM $MgCl_2$, 9 mM $ZnCl_2$ [4]. The relaxation times of the phantom were adjusted by adding 0.5 mM DOTAREM. A concentration of 1 mM TMS and 10 mM Na formate provide a reference at 0 ppm and 8.44 ppm, respectively. The surrounding fat compartment was filled with sunflower oil and the water tank with tab water.

## Measurement

All measurements were performed on a 3T GE Excite HD Signa Scanner with the body coil. A T1-weighted fast-spoiled gradient-echo sequence was acquired for planning the spectroscopy voxel. A spectrum was acquired by using the over-prescribed PRESS sequence with TE = 26 ms, TR = 2000 s and 128 signal averages.

## Results and Discussion

The prostate phantom nicely mimics the problems of *in vivo* MRI and MRS. It is similarly problematic to acquire spectra in the phantom due to the air in the rectum and the surrounding fat layer. The signal-to-noise ratio (SNR) is low due to acquisition with the body coil. SNR could be significantly improved by using an endo-rectal coil. In summary, the phantom provides a good training tool and will be helpful for testing hardware such as endo-rectal coils. It can further be used for quality assurance.

## References

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