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A 282 GHz Probe for Dynamic Nuclear Polarization

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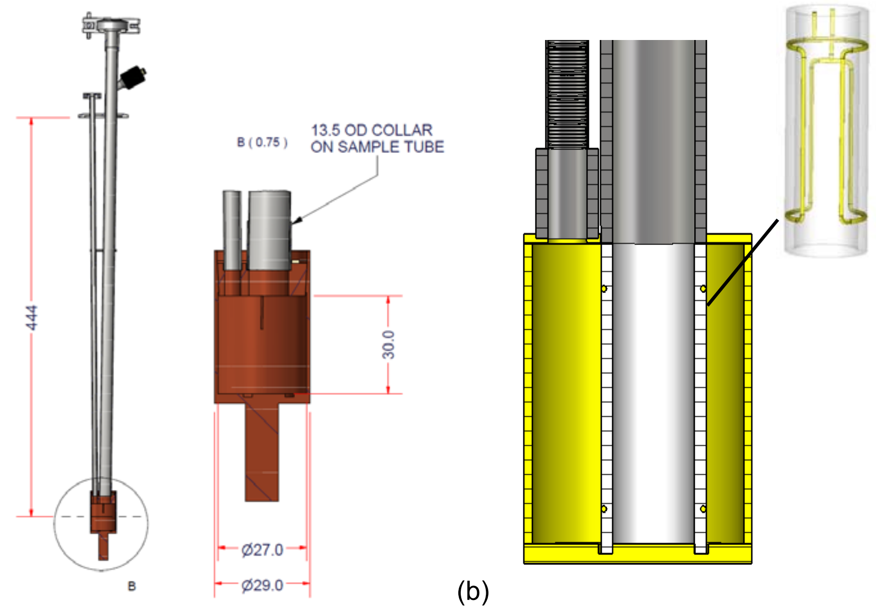
Introduction In DNP, microwave irradiation of a sample facilitates the transfer of spin polarization from electrons to nuclei. One of the way to improve the DNP enhancement is to transfer microwave power from the mm-wave source to the sample more effectively. Several methods and techniques to efficiently transport microwave energy from the microwave source to the sample have been developed. For example, a corrugated waveguide allows to deliver mm-wave energy from external source to the probe with minimum losses[1].The conventional approach at high frequencies is to irradiate the sample directly from the waveguide[2,3], while at low frequencies the cavity of the probe is used as a microwave resonator[4]. It is important to optimize the arrangement of microwave, RF and sample handling components. In this paper a solution for the double channel microwave probe for operation at 10.1 T (^{13}C frequency is 108 MHz, ^{1}H frequency is 430 MHz, electron frequency is 282 GHz) is developed. The construction of the probe is detailed.

Probe configuration The analysis of the probe structure is performed using a full-wave electromagnetic simulator (CST Microwave Studio 2014). Structurally, the probe consists of two sections: microwave can with RF coil; the rest of the probe consists of a waveguide, sample tube and coaxial transmission line. The probe is designed to study cylindrical samples with diameter - 9 mm, and height – 2-20 mm. An RF coil which is housed in cylindrical Macor coil form (dielectric with ε=5.64 and tangent δ is 0.0025) surrounds the sample. The RF coil has a saddle form and was made out of two current loops run on opposite sides of a cylinder (in parallel). Material of the coil is copper wire with diameter equal to 0.7 mm. Coil dimensions are: diameter - 13 mm; height - 22.0 mm. The self resonant frequency of the coil is 976 MHz. A magnetic field distribution at 108 MHz and 430 MHz was calculated for the RF coil, the results revealed good homogeneity and intensity along x,y,z axes. **Figure 1** shows the general view of the probe and cross section through the microwave container with field distribution. Operating frequency is 282 GHz to drive DNP. On the top of the model is mounted a corrugated, circular waveguide.



(a) (b)

Figure 1. The general view of the probe (a), cross-section view of a probe including RF coil (b)

To avoid losses and to maintain the constraint that the RF coil surrounding the sample should not to be close to metal parts. An additional advantage of using the corrugated waveguide is that the losses and power dissipation in free space are negligible. In our construction of the probe we have optimized relevant parameters of the probe.

Conclusion We have demonstrated the feasibility of the probe design for DNP applications at 10.1 T from the microwave and RF point of view. The performance simulations of the microwave cavity have demonstrated that the electromagnetic field is effectively concentrated at the sample location.

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