A large volume multi-samples DNP Polarizer dedicated to MR biomedical applications

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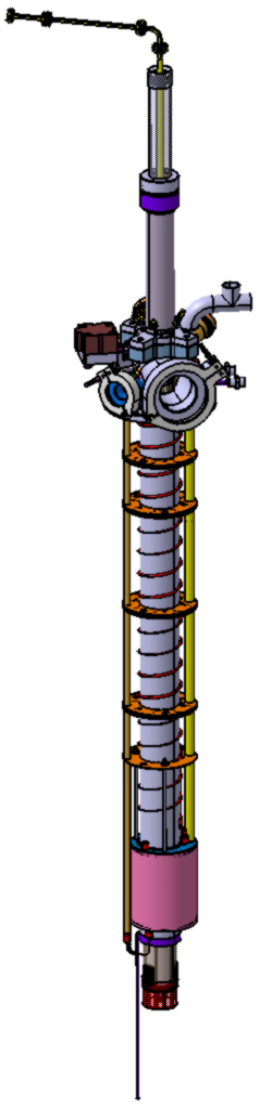
Introduction

In recent years Dynamic Nuclear Polarization has been used to produce solutions of hyperpolarized ^{13}C or ^{15}N labeled metabolites [1, 2] opening the way to new promising biomedical applications [3, 4]. The current polarizers produce single batches of hyperpolarized solution, with a minimal delay between batches of several hours. Some biomedical applications would benefit from a polarizer producing batches of contrast solution in shorter time laps. In this aim, we propose a polarizer design adapted to mono or multi-samples production. The multi-samples mode allows separate extraction of samples without affecting the temperature, hence the hyperpolarization of the remaining samples, which can then be extracted sequentially over a short time period.

Polarizer design

This abstract focuses on the design of a new polarizer. The polarizer is a variable temperature cryostat, inserted into the room temperature bore of a 400 MHz Bruker Magnet ramped down to 3.35T. Its basic principle, concerning the cryogenic parts, is similar to that described in reference [2], but the large bore diameter (150 mm) results in a larger volume of the RF cavity, allowing to produce either larger samples or multiple batches. The cryostat contains a 2 liters He^4 bath pumped down to 1.2K and continuously refilled from an outer storage Dewar. Carefully designed radiation shields reduce the heat losses, hence the minimal temperature. The millimeter wave system used to polarize the sample is optimized to propagate 94 GHz wave from the 200mW source to the sample. Stainless steel oversized waveguides, designed using finite elements numerical simulations, limit the electromagnetic leaks and the thermal transfer, hence the impact on the cryostat temperature. The horn antenna is coupled to the millimeter wave cavity and focuses the power onto the sample allowing the efficient build-up of polarization. Polarization is controlled by low angle NMR pulses applied to a volume coil. Tuning and matching are performed using a pre-tuned low-temperature circuit and a remote room-temperature standard circuit. A top-loaded holder positions the sample(s) at the magnetic center of the magnet, with a central access used to insert the waveguide in the polarization phase, and the dissolution insert in the extraction phase. The design allows continuous pumping of the cryostat, except during the waveguide replacement by the dissolution insert. The dissolution insert is designed to maximize the concentration of the hyperpolarized solution. In the mono-sample configuration, the whole sample is dissolved and extracted with minimal impact on the helium bath, allowing to immediately repeat a new cycle of polarization / extraction. In the multi-sample configuration, the remaining samples are protected from heat transfer from the warm dissolution insert and maintained at low temperature and high field to keep their hyperpolarization until their extraction.



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Conclusion

This work describes the different components (magnet, cryostat and millimeter wave system) of a multi-batches polarizer for in vivo MR imaging of biomolecules. The possibility of producing several samples within short time intervals will increase the range of biomedical applications.

References

[1] Ardenkjaer-Larsen et al. – *P. Natl. Acad. Sci. U.S.A.* 100 (2003) 10158-63
[2] Comment et al. – *Concepts Magn. Reson. B* 31 (2007) 255-269
[3] Gallagher et al. – *Nature* 453 (2008) 940-943
[4] Albers et al. – *Cancer Res.* 68 (2008) 8607-8615