Palpating Particles Using the Acoustic Radiation Force

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INTRODUCTION

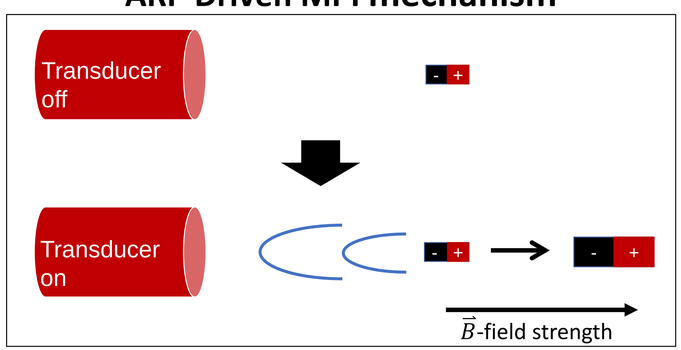
Traditional MPI
- Shelf stable tracer particles
- No ionizing radiation
- Bulky MR-like hardware limits accessibility
- No background anatomical image
- Simultaneous transmit/receive

Bruker Biospin Preclinical MPI

ARF Driven MPI
- Inherently co-registered background anatomical image from b-mode image
- Handheld & Portable

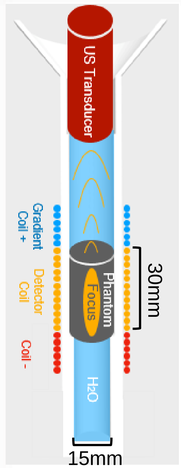
https://www.auntminnie.com/clinical-news/ultrasound/article/15621354/ergonomic-training-may-help-sonographers-avoid-msk-injury

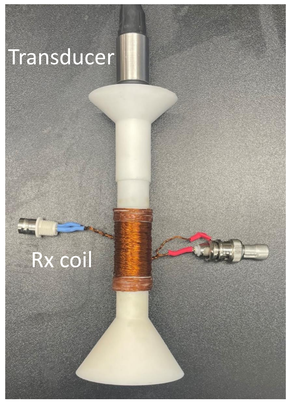
ARF-Driven MPI mechanism



Iron nanoparticles, represented here by bar magnets, are displaced tens of microns when “pushed” or palpated by an acoustic radiation force. When a field gradient is present in the direction of palpation, the magnetic moment of these particles will change.

SET UP



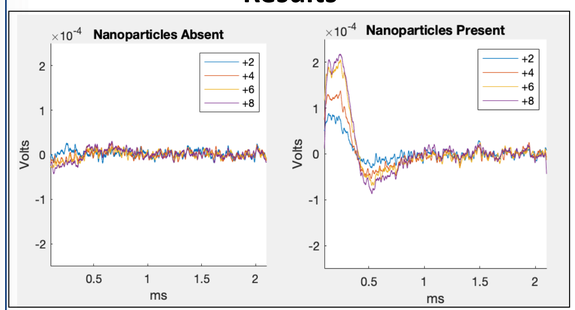


- 5MHz F#4 transducer
- Rx coil with 78 turns of 4/28 litz wire
- 1% W/V agar, 4% W/V graphite phantoms with and without Vivotrax nanoparticles

Phantom without particles | Phantom with particles

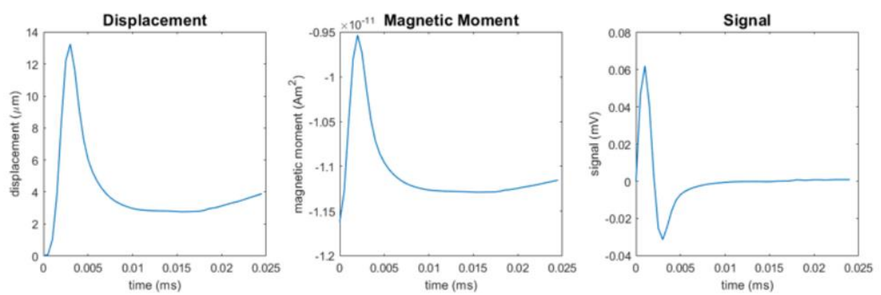
First Signals with Long Pulses: Simulation vs Experiment

Results

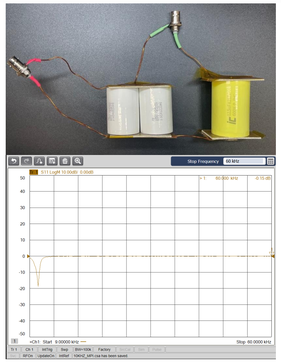


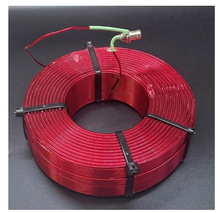
- FEM simulation performed to calculate displacement[1]
- MPI signal calculations undertaken for generated displacement maps[2]
- Reliable signal required an unattainable number of averages

Simulation

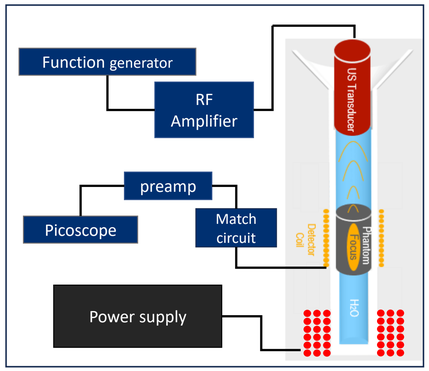


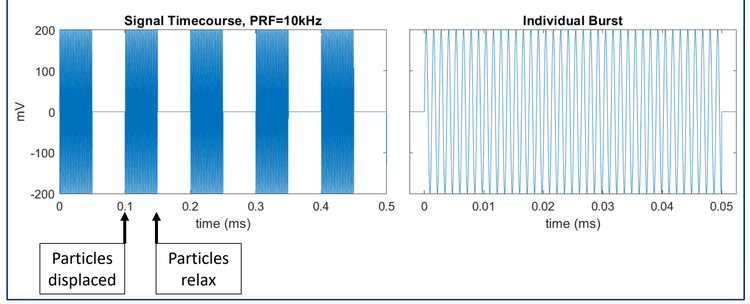
2nd Generation: Tuned coil with Rapid PRF





- Tune Rx coil to 10kHz
  - Tune=4μF
  - Match=12.5μF
- Pulse US at PRF of 10kHz
  - Expect signal at 10kHz
- Shielding





REFERENCES

[1] Palmeri, M. L. et al (2005). A finite-element method model of soft tissue response to impulsive acoustic radiation force. *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency*
[2] Bringout, G (2014) Basics of MPI [Source code]. https://github.com/gBringout/BasicsMPI

ACKNOWLEDGEMENTS

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