Tools and methods for low field MR imaging and elastography

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What is low field MR?

MRI ≤ 0.1 T, much lower field than today's clinical scanners:

- ✓ accessibile & flexibile: siting, $, maintenance, ...
- ✓ less ferromagnetic "bullet" risks
- ✓ less "iron" susceptibility artifacts
- ✓ less complicated coil optimization

But it does not mean "simple":

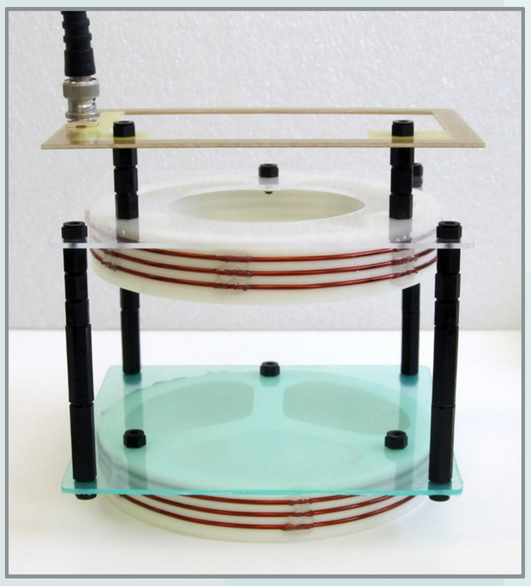
- x less signal = longer scan time
- x fine resolution is harder (but not impossible!)
- x smaller magnets often are more inhomogeneous
- x many components must be custom-made

What do we work on?

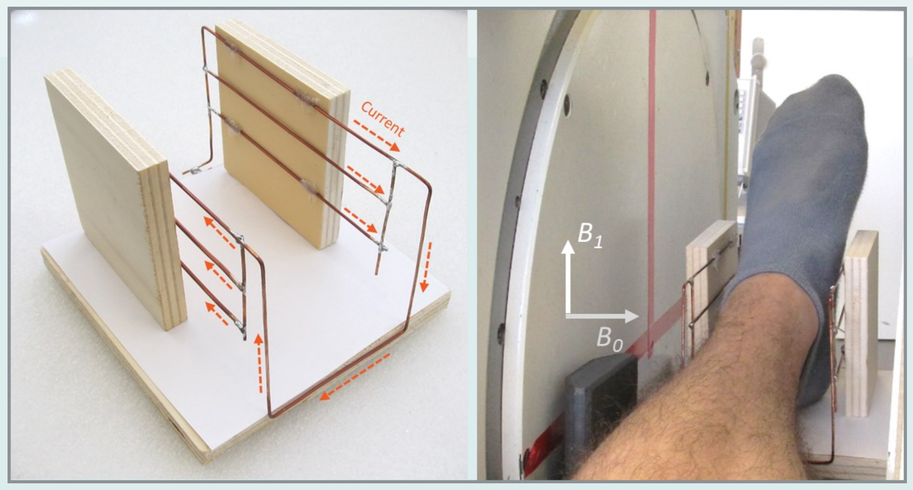
Optimized detectors: RF coils @ 4.2 MHz

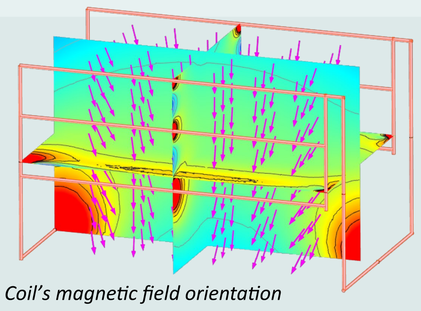
If carefully designed and built, they may boost the MR signal or lower the noise, allowing faster scans. Open-access coils enable adaptable, flexible applications (e.g. MRE, interventional MR, imaging with orthopedic implants).

Open RF coil for MR Elastography

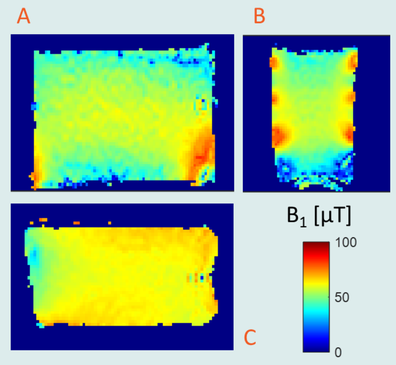


Open-access RF coil

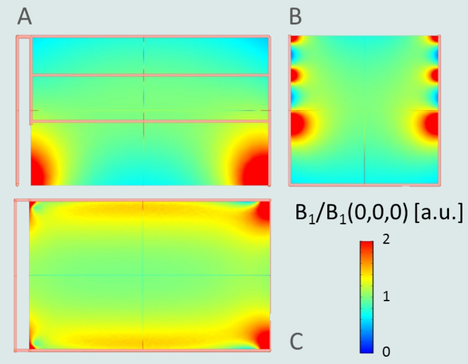




Coil's magnetic field orientation



Acquired maps of the coil's magnetic field



Simulation of the coil's magnetic field

MR Elastography

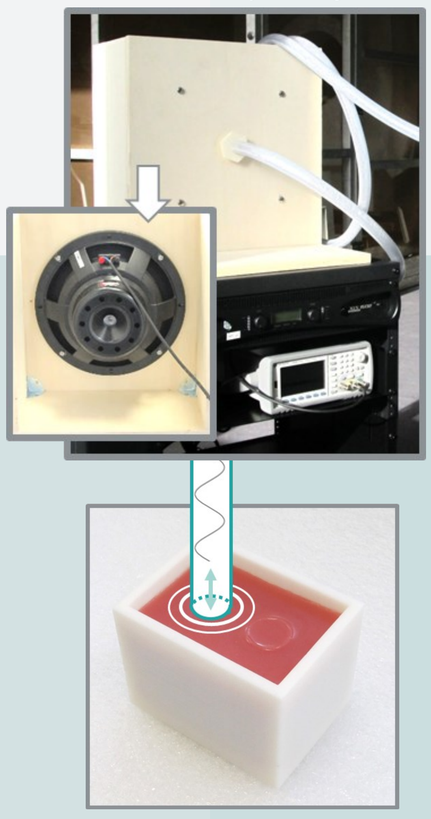
MRE quantifies the mechanical properties of organs, such as stiffness and viscosity.

It requires 3 ingredients:

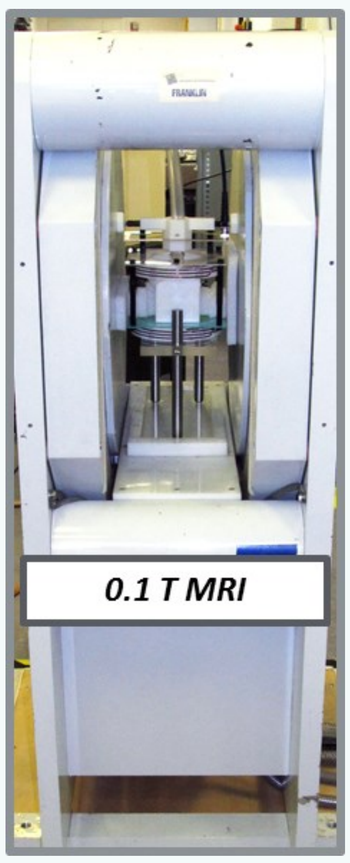
- wave propagation in the body,
- a motion-sensitive MR scan to capture the wave motion,
- mathematical inversion of raw data into diagnostic maps.

Often used for liver fibrosis, MRE becomes unreliable at clinical magnetic fields when iron accumulates in organs.

Custom MRE hardware for wave generation



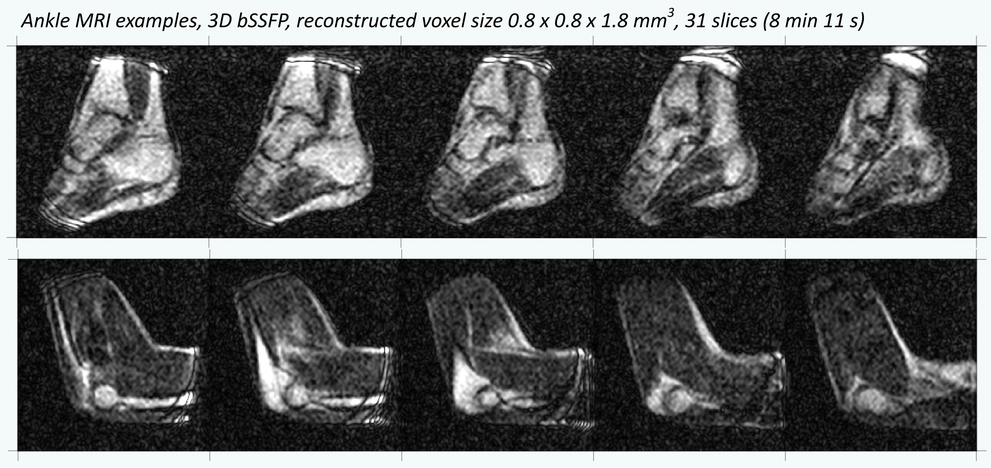
MRE vibration on a silicone phantom



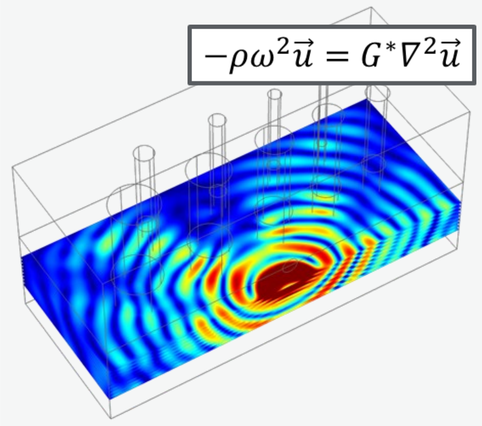
Dedicated MR sequences

optimized for our hardware and magnetic field to speed up MR scans despite many challenges (e.g. low signal, unshielded scanner, B_0 inhomogeneity, no commercial sequences).

Ankle MRI examples, 3D bSSFP, reconstructed voxel size 0.8 x 0.8 x 1.8 mm^3, 31 slices (8 min 11 s)



Elbow MRI examples, 3D bSSFP, reconstructed voxel size 0.8 x 0.8 x 1.8 mm^3, 31 slices (10 min 55 s)



Wave simulation for synthetic MRE data

Simulations

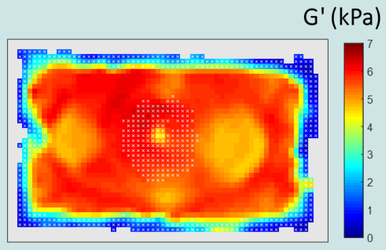
enable accurate optimization of a coil's magnetic field or provide synthetic MR data for validating Elastography reconstructions.

Phantoms

mimicking anatomical shapes or ideal objects with a controlled geometry for testing MR sequences or different magnetic & mechanical properties for validating MRE methods across various magnetic fields.

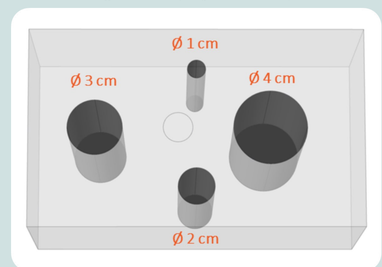
Molded silicone foot

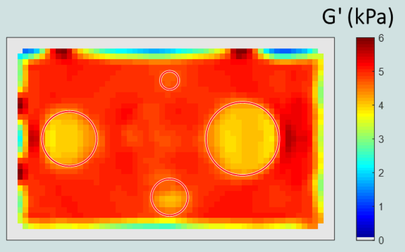
Silicone phantom for MRE



Stiffness maps from MRE on the phantom at 3 T

Simulated geometry of the real phantom





Stiffness maps reconstructed from synthetic data

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