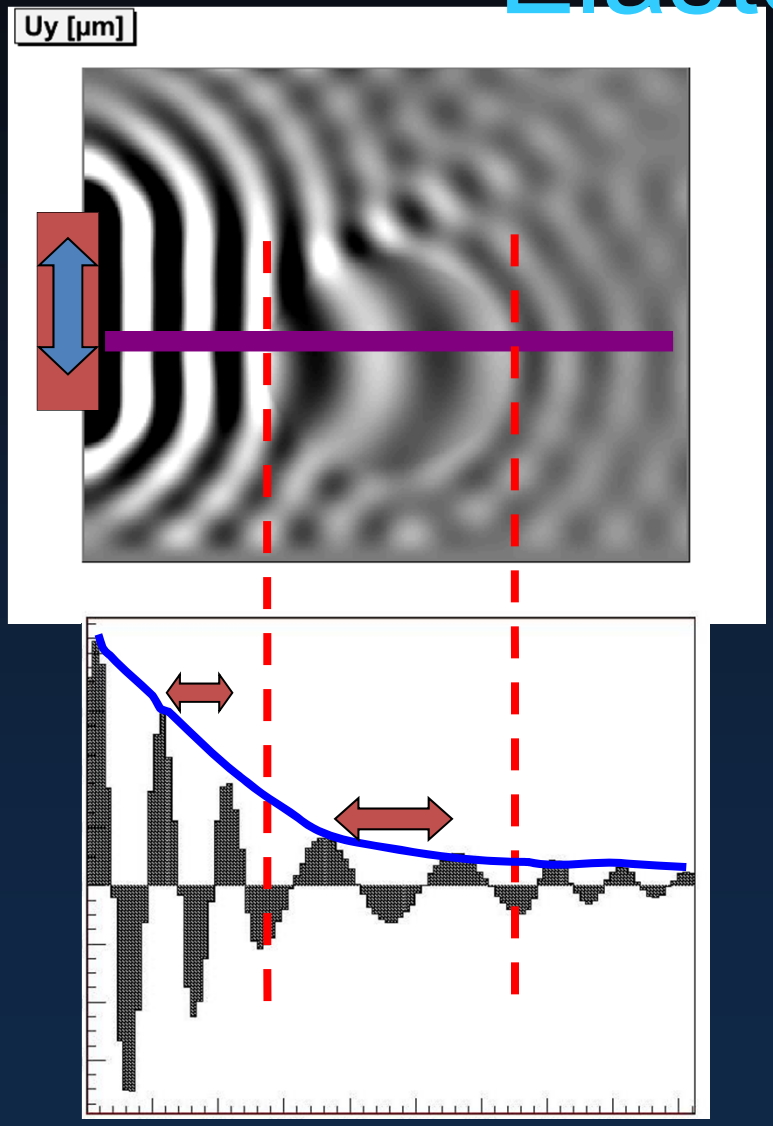
MR Elastography: Measuring brain mechanical properties in vivo

A Practical Guide

Lynne E. Bilston

Magnetic Resonance Elastography



Wavelength changes according to local stiffness

elasticity

$$\mu = \rho\omega^2\lambda^2$$

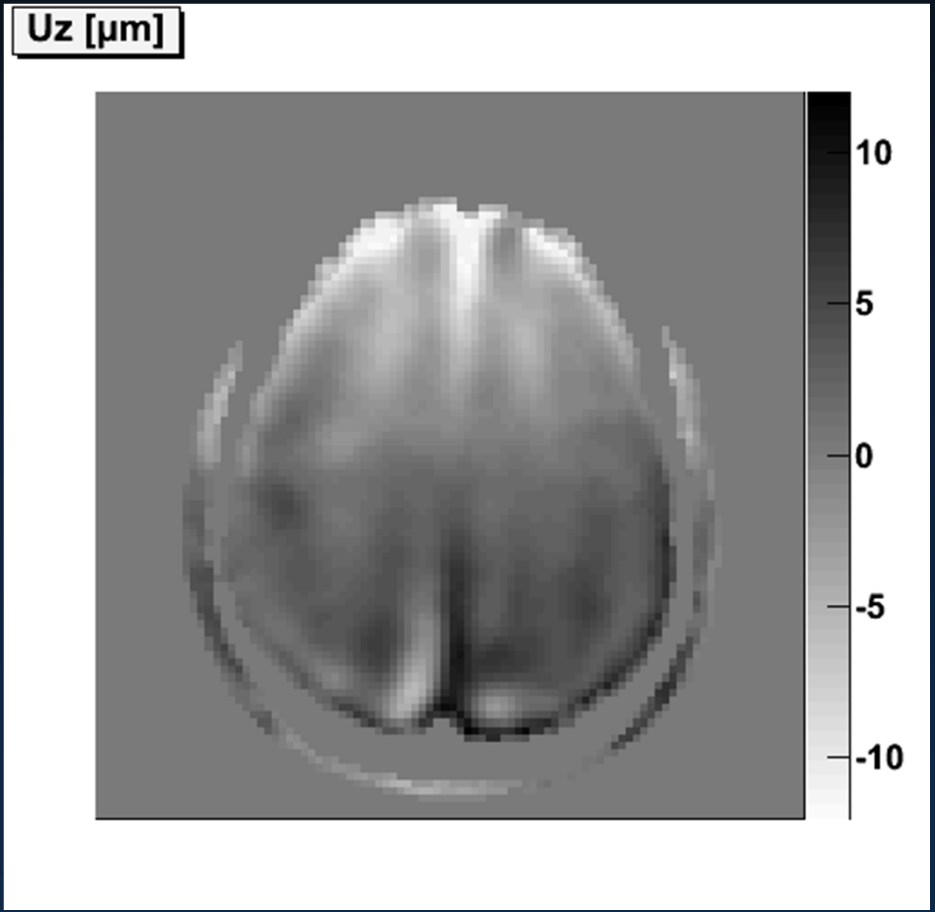
Amplitude of wave is reduced due to viscosity

viscosity

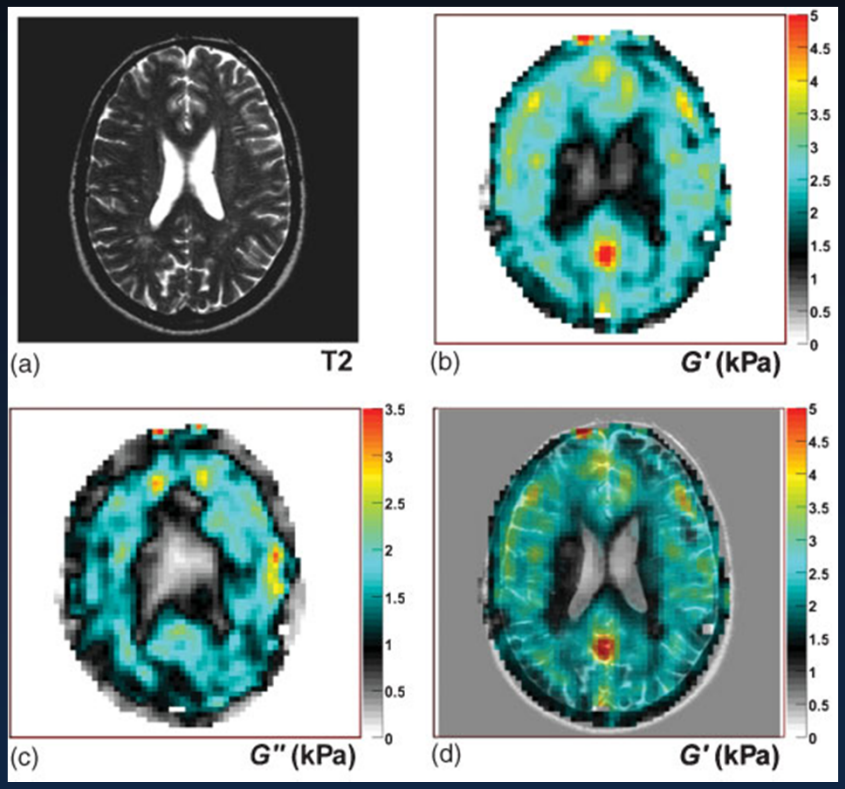
Diagram from R. Sinkus

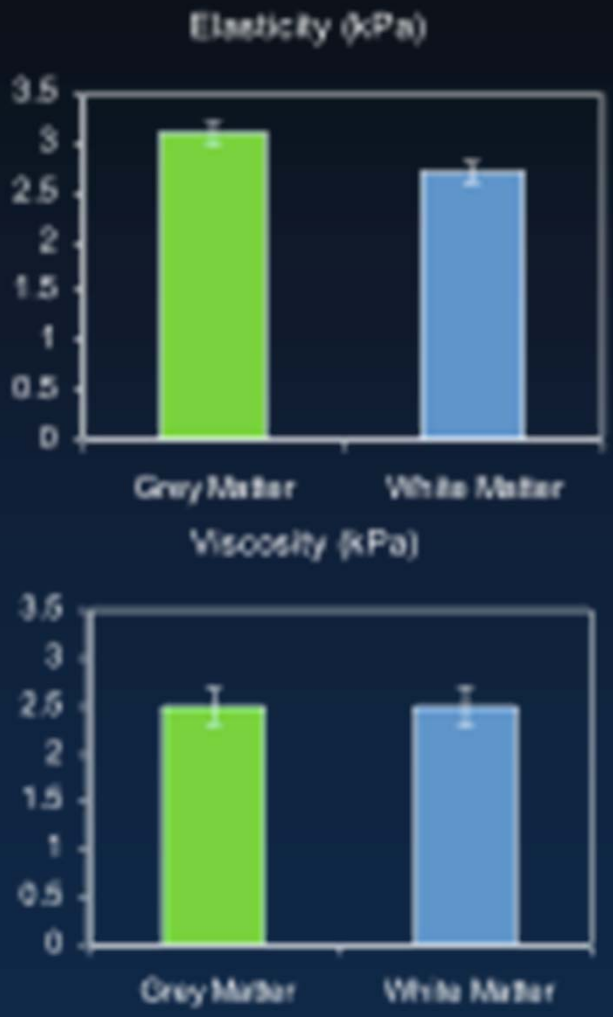
Brain MRE

- Vibration propagated into the brain through the skull
- Human and animal studies have been performed
- Isotropic and anisotropic properties have been measured
- Grey and white matter



Normal Brain MRE

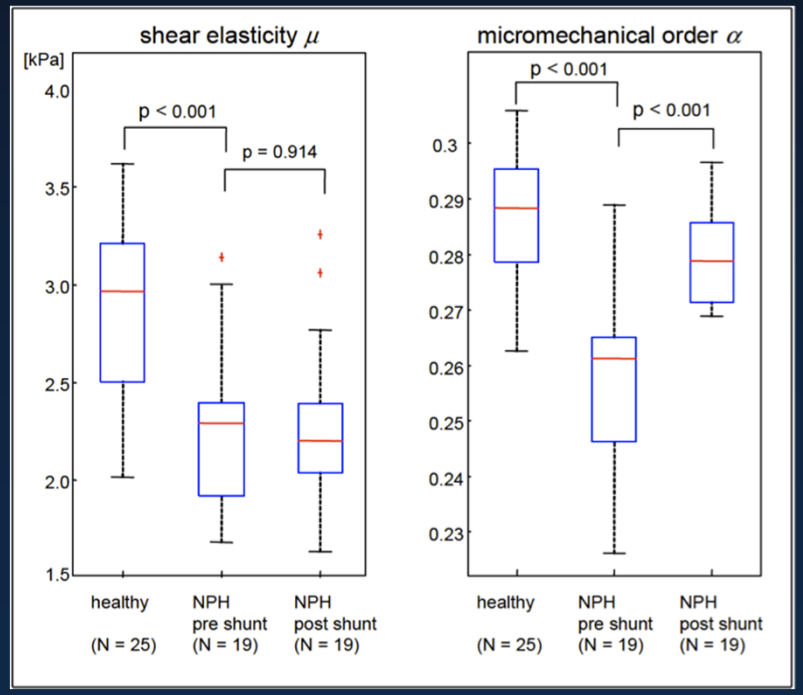


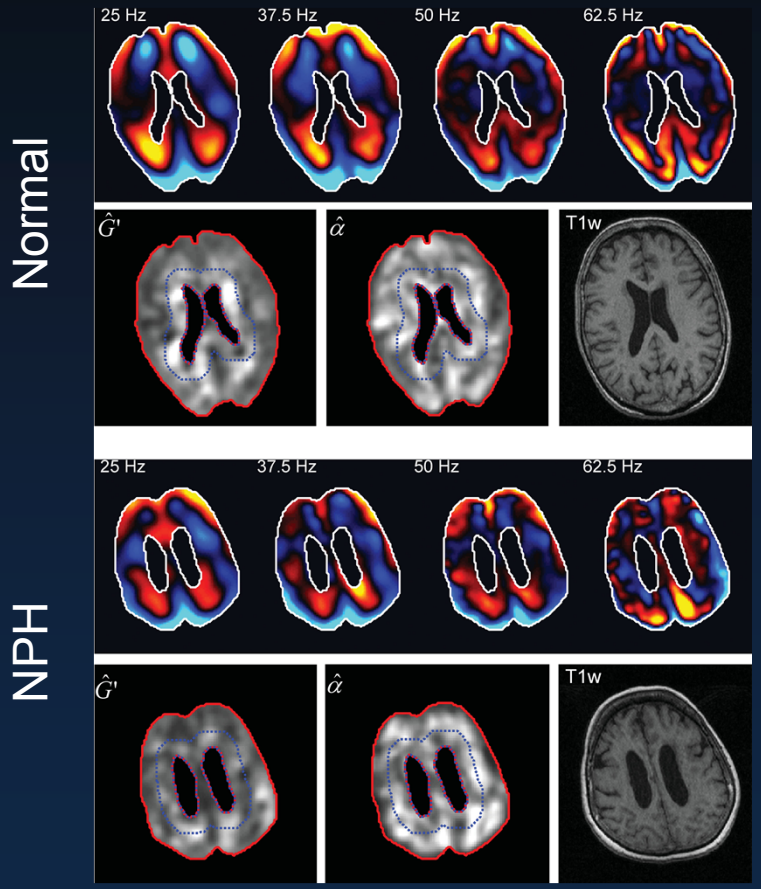


Green et al, NMR Biomed 2008

MRE in NPH

- One group has measured brain elasticity in NPH patients (Streitberger et al, NMR Biomed 2010; Sack et al ISMRM 2011)





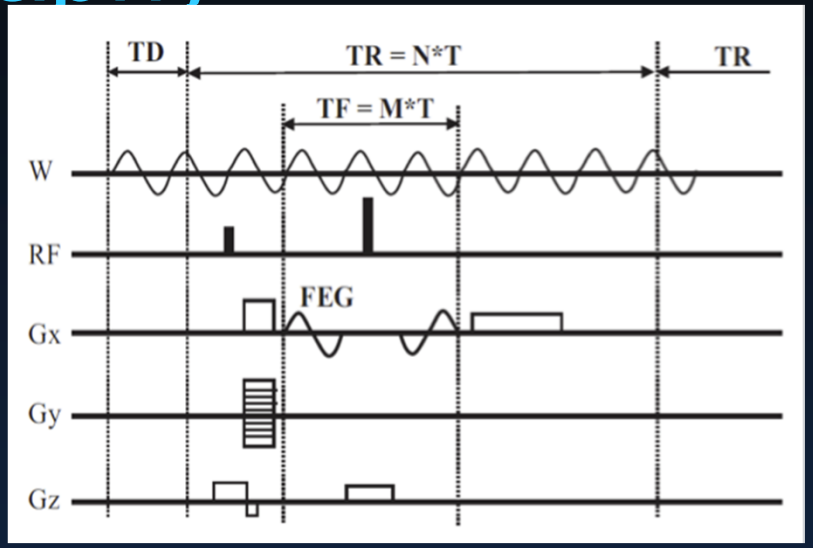
- Substantial variability, limited specificity

What do you need to do MRE?

- MR pulse sequence
  - To drive the MR scanner
- Transducer
  - To create the vibration
- Analysis software
  - To calculate the brain mechanical properties

MR Pulse Sequence for elastography

- Some different types
  - Spin echo
  - FFE etc
- Motion encoding gradients, synchronised with mechanical vibration measure displacement at specific points during vibration cycle
- There are sequences available for Philips, Siemens, GE scanners
- Implementations still in the ‘research’ phase for brain.
- MRE can be done on 1.5T or 3T scanners
- Scan time varies depending on sequence type (~4mins-15mins)
- Can add DTI for anisotropy

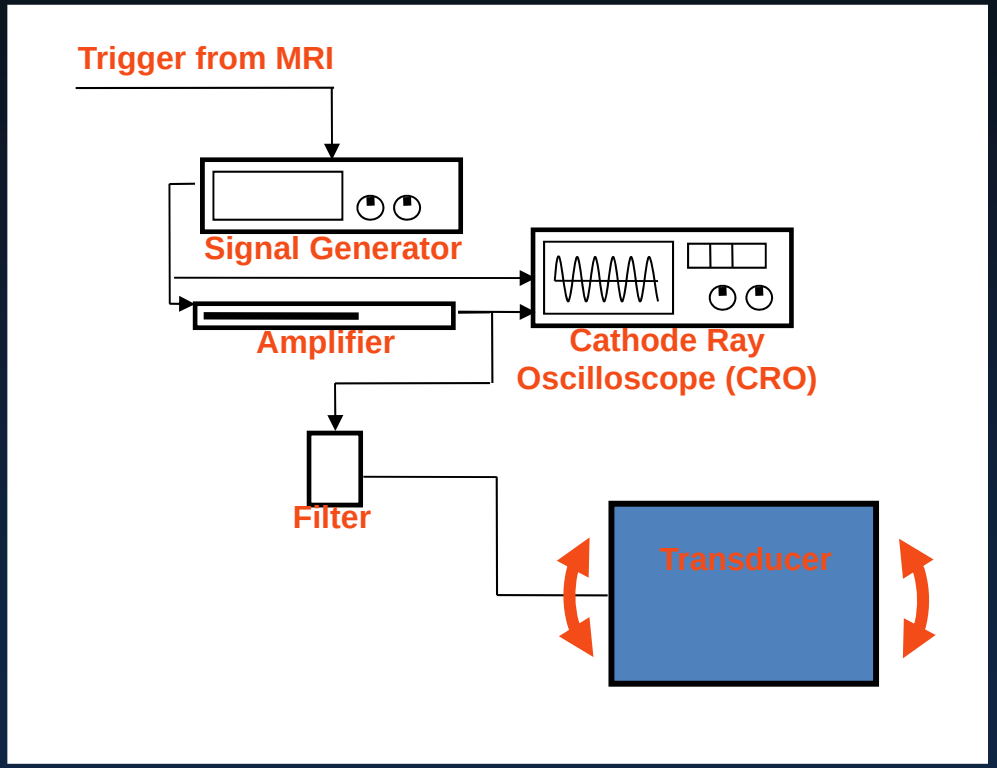


Sinkus et al, Phys Med Biol 2000

Transducer and hardware

Equipment needed:

- Programmable function generator
- Amplifier
- Connections to scanner & transducer
- Filters for pass-through into scan room
- Transducer
- No commercial packages for brain elastography



Transducers for Brain MRE

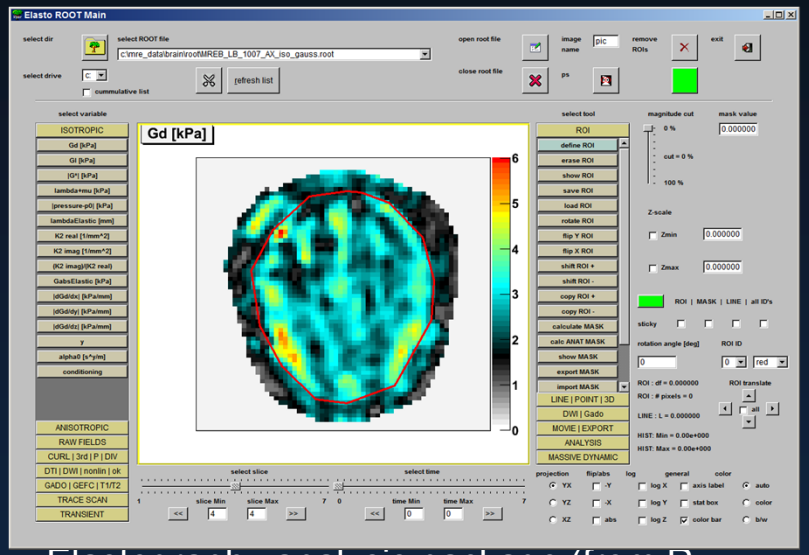
- Two main types
  - Mouthguard
  - Head rocker
- Neither are ideal for all subjects

Sydney Brain Transducer + coil driven mouthguard

Berlin group head rocker transducer

Analysis

- Many implementations of analysis
- Outputs include:
  - Shear modulus (G) – a measure of stiffness
  - Shear elastic modulus (G', μ)
  - Shear viscous modulus (G", ωη)
  - Various other implementation specific parameters
- Vendors can supply software to read specific scanner formatted files
- Most vendors have software to do basic analysis (from their liver packages)
- One freely available application (MRE/wave) does elasticity only



Elastography analysis package (from R. Sinkus)

Summary

- To do MR elastography, you need:
  - MR pulse sequence
  - Transducer & associated hardware
  - Analysis software
- Brain elastography is not yet a commercial product
  - Transducers are mostly ‘custom made’
  - Software often implementation-specific
- Limited comparison has been done across sites and scanners/implementations
- Lots of different details – frequencies, sequence, transducer, analysis