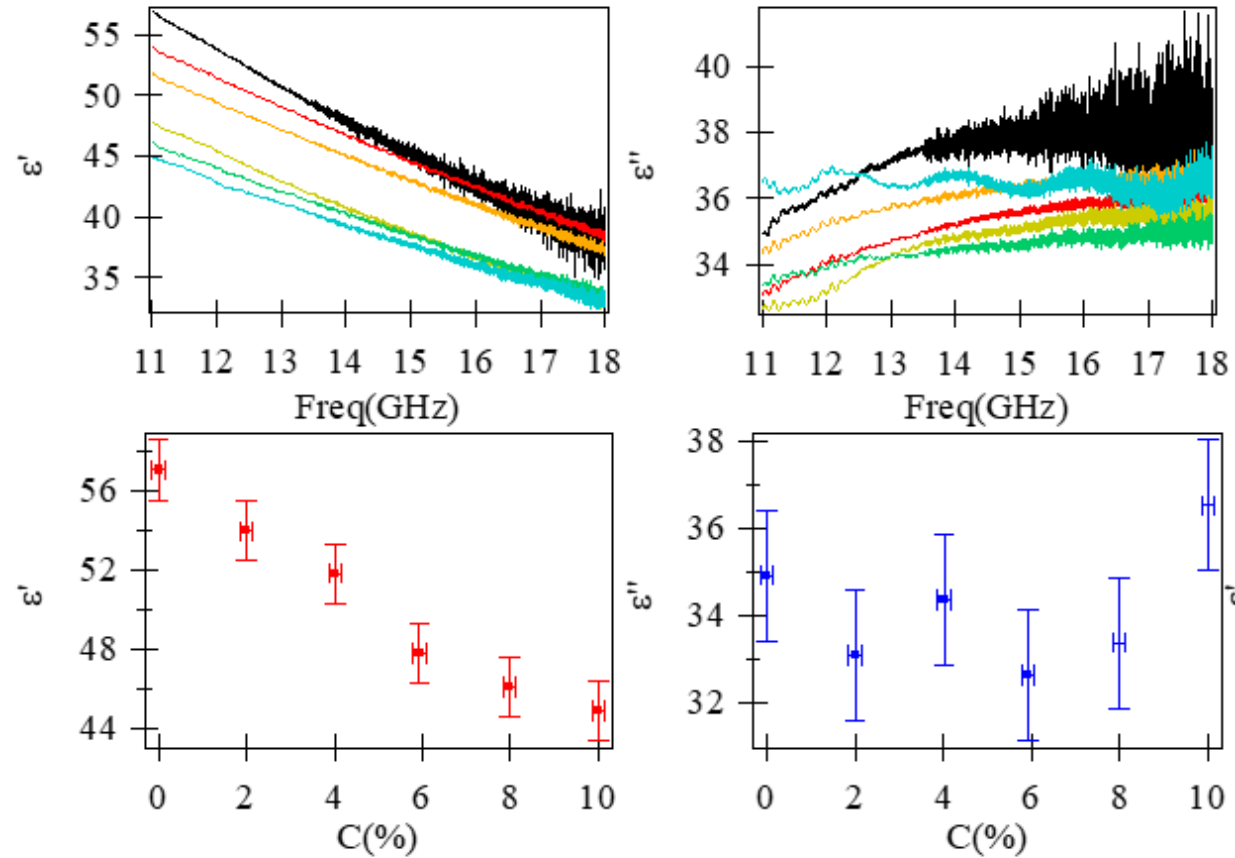# DRDC project results
and
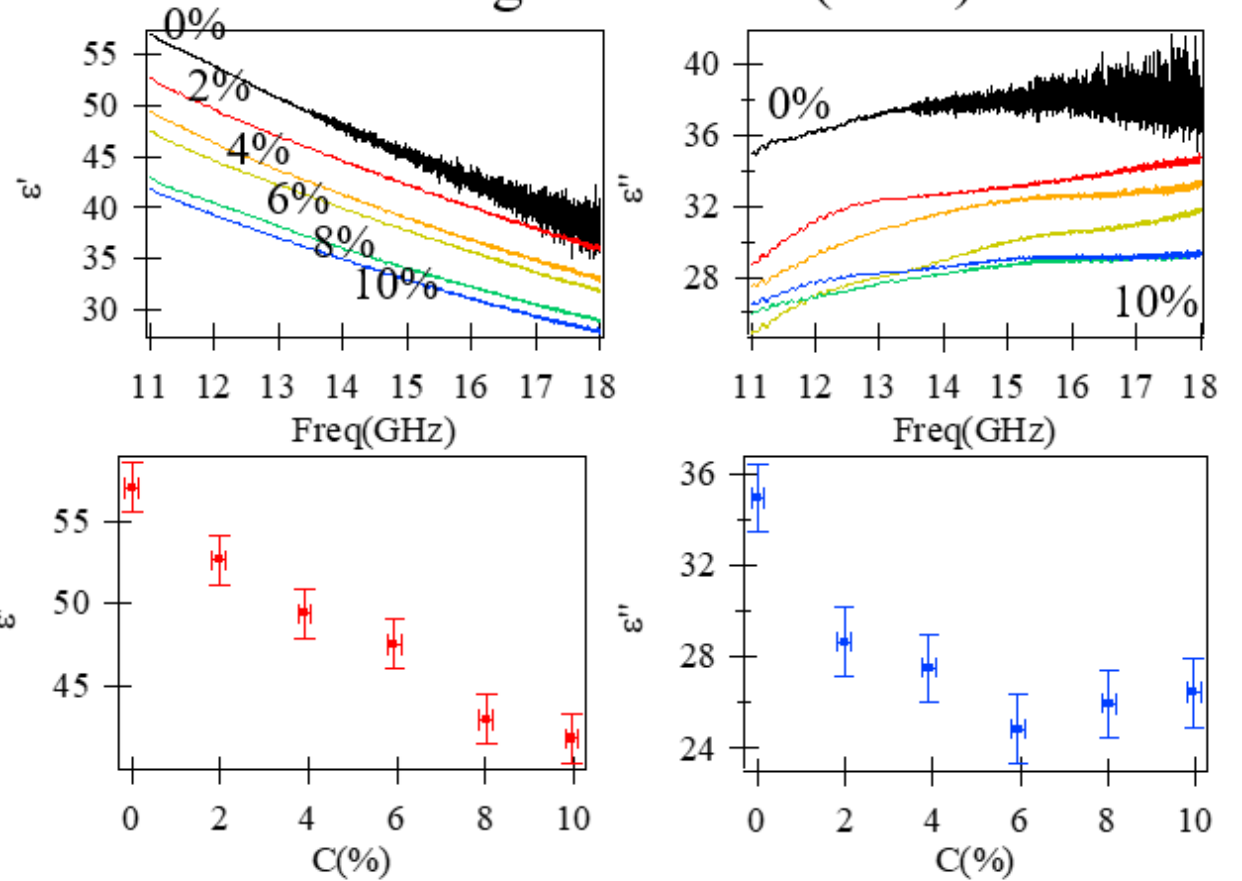# Magnetic nanoparticle imaging

Yutong Zhao

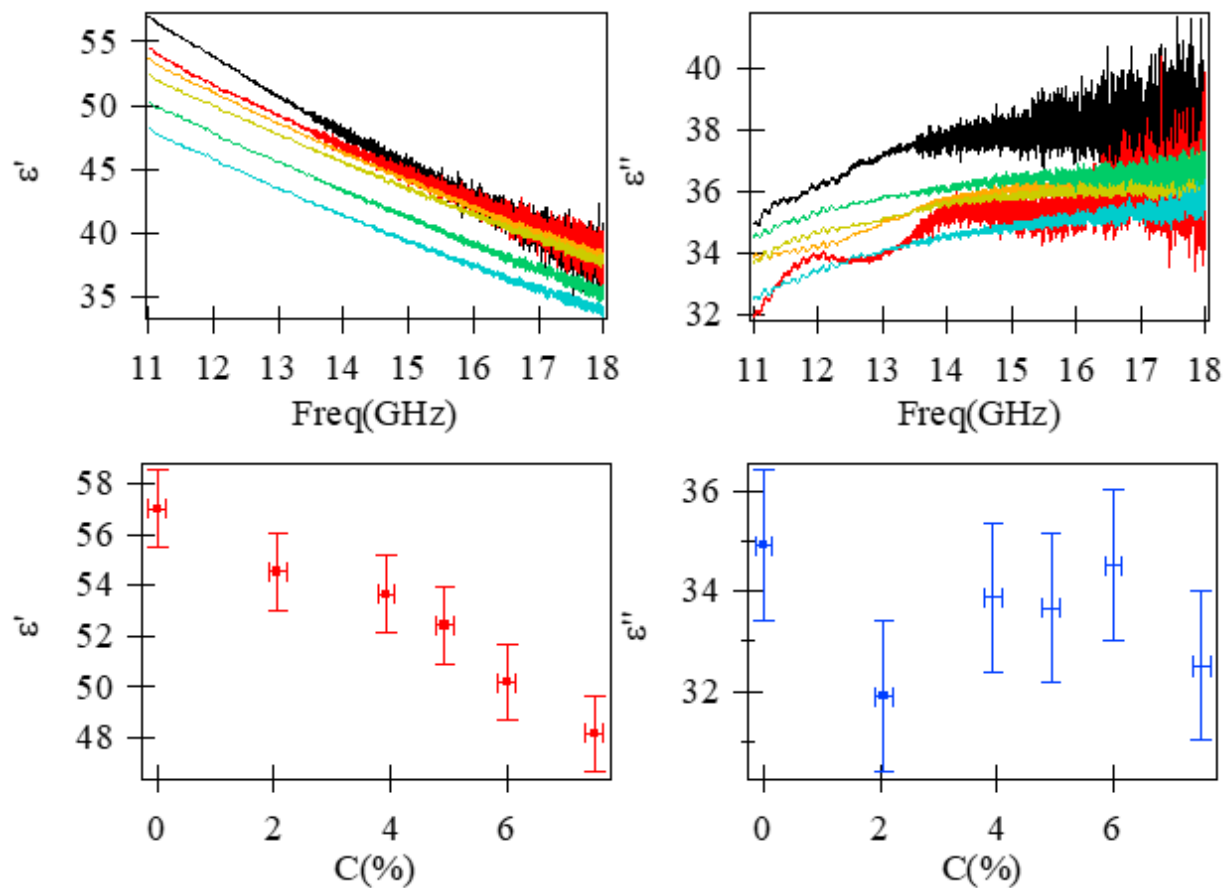Jan 28th 2019

DRDC project results

KNO$_3$ solution (1mL)

Sugar solution (1mL)
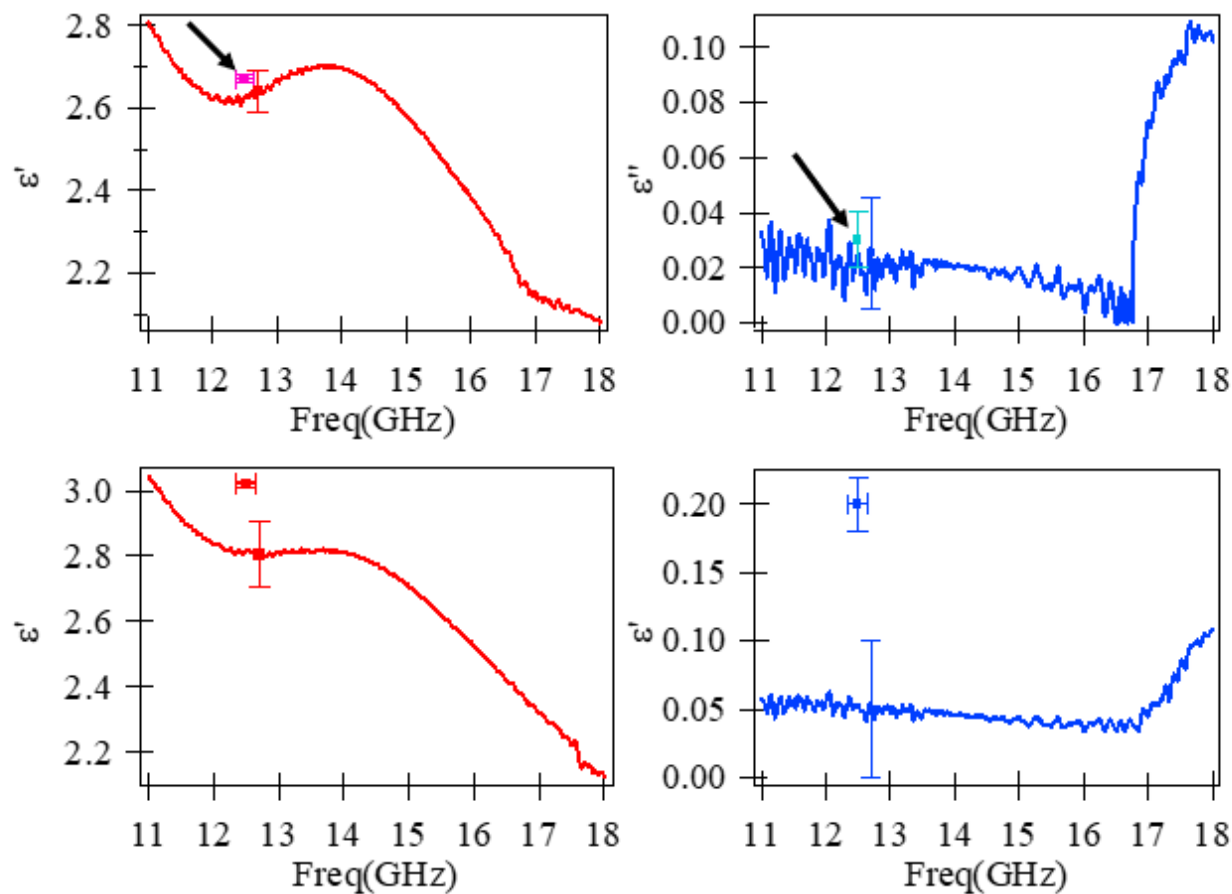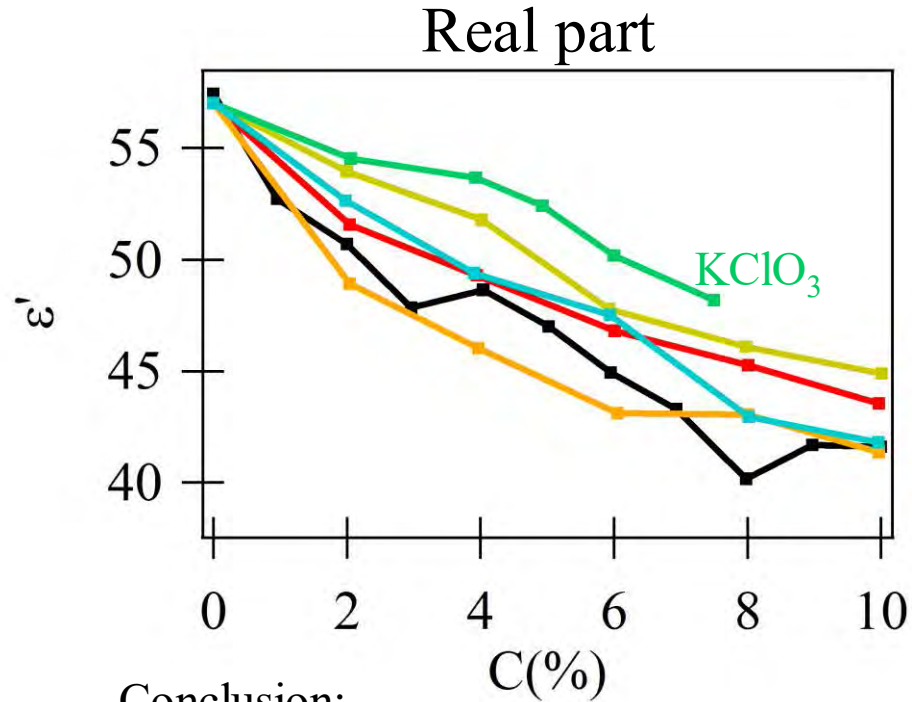
DRDC project results

KClO$_3$ solution (1mL)

Car diesel fuel

Car gasoline fuel

Summary of solutions

Real part   Imaginary part

KClO$_3$

NaCl
NH$_4$NO$_3$
NaNO$_3$
KNO$_3$
Sugar

ε' C(%) ε'' C(%)
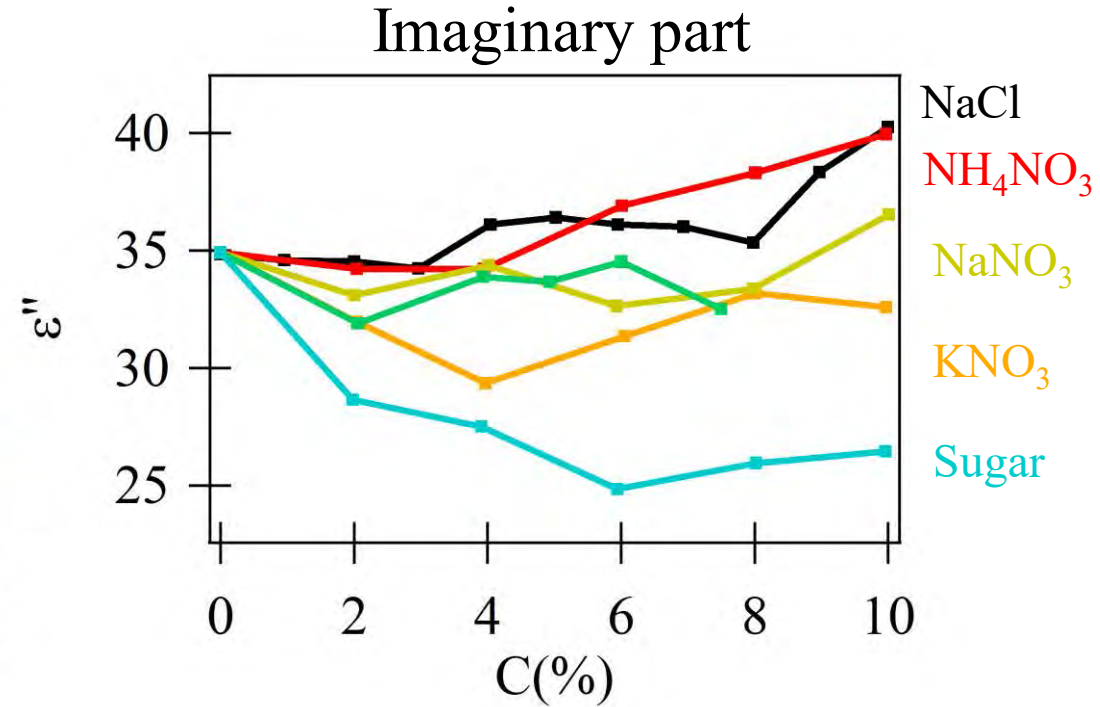
Conclusion:

- We determined 5 ionic solutions and 1 molecular solution.

- Real part: all of these solutions decrease with the concentration (C).

- Imaginary part: NaCl, NH4NO$_3$ increase and Sugar drops with C.
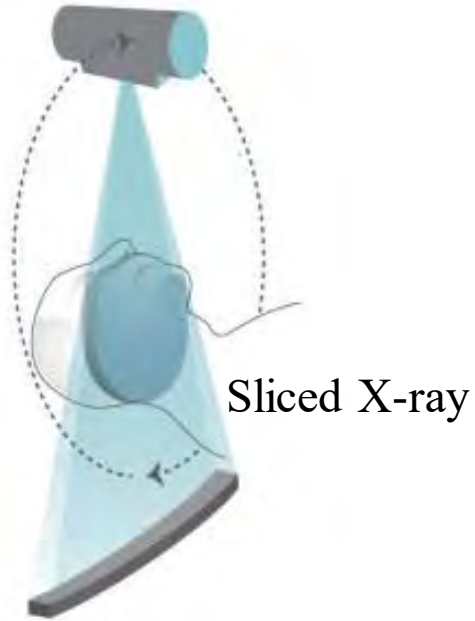
Remaining problem:

- For gasoline, it has been stored 1 year. The high evaporation property may result the difference.

    Solution： get some fresh gasoline from gas station.

Medical imaging methods
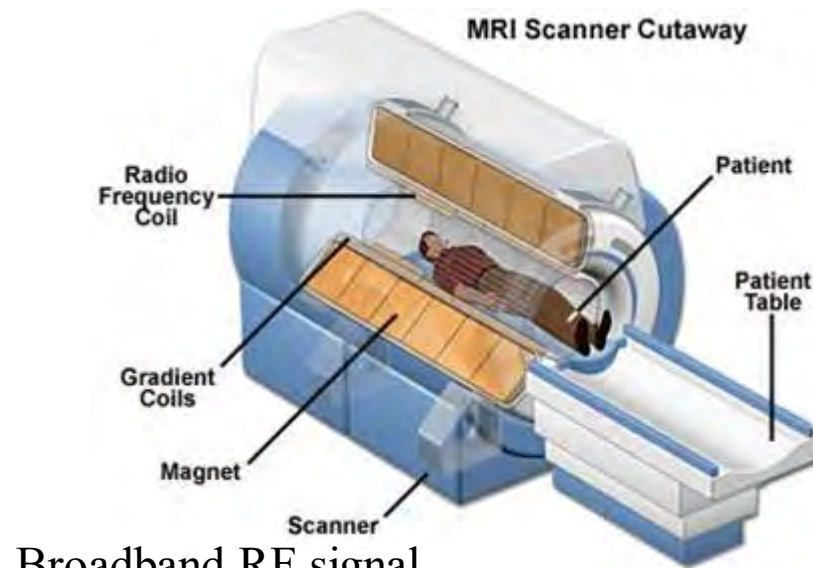
1. Computed Tomography(CT)
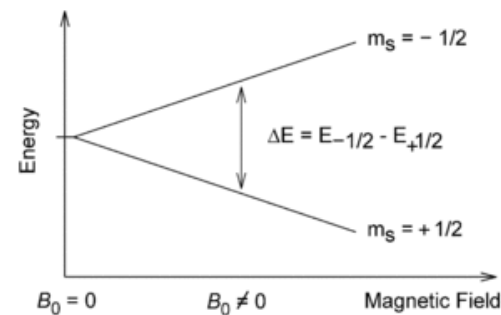
Sliced X-ray

Beer–Lambert law
$$I = I_0 e^{-\alpha d}$$

α – attenuation factor
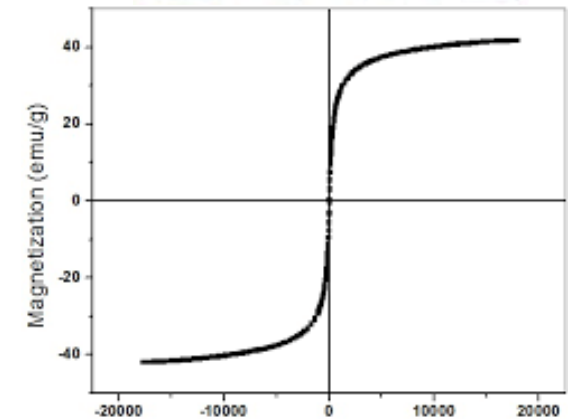
2. Magnetic Resonance Imaging(MRI)

MRI Scanner Cutaway

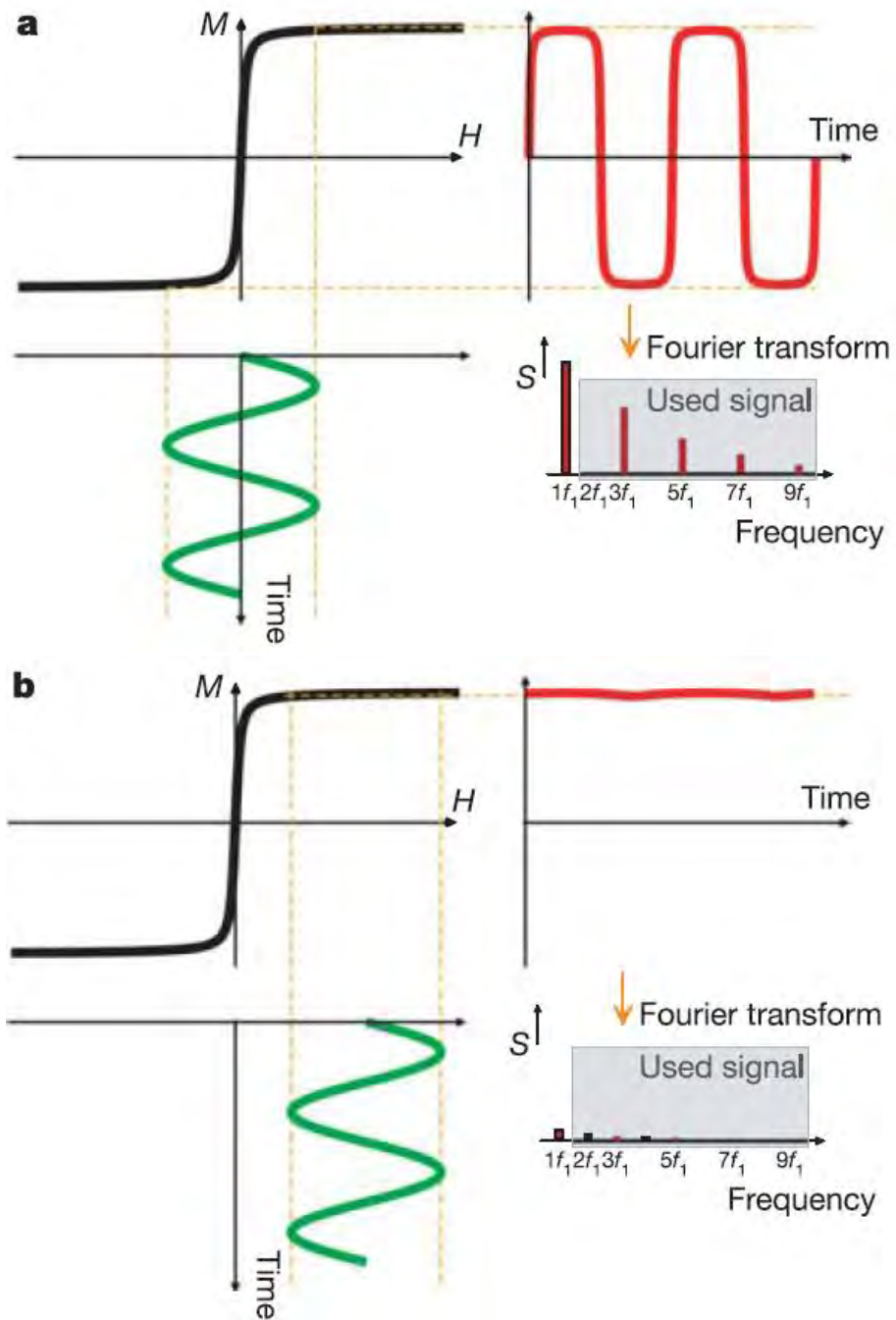Radio Frequency Coil

Patient

Gradient Coils

Patient Table

Magnet

Scanner

Broadband RF signal

γ- gyromagnetic ratio

$\Delta E = \gamma \hbar B$

Energy

$m_S = -1/2$

$\Delta E = E_{-1/2} - E_{+1/2}$

$m_S = +1/2$

$B_0 = 0$ $B_0 \neq 0$ Magnetic Field

3. Magnetic Particle Imaging(MPI)

B

H

10–20 nm

Magnetization (emu/g)

40

20

0

-20

-40
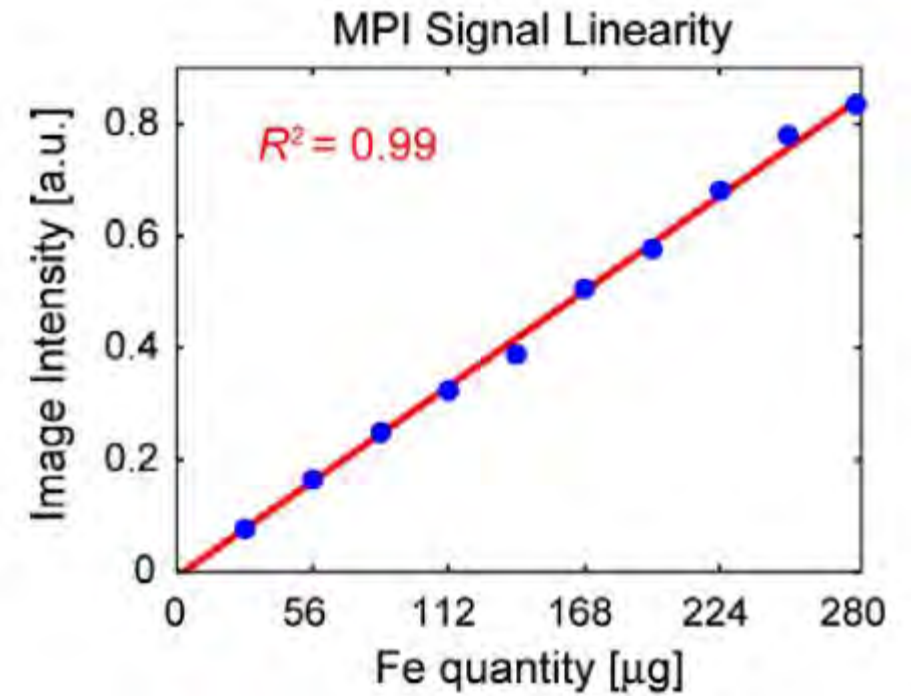
-20000   -10000   0   10000   20000
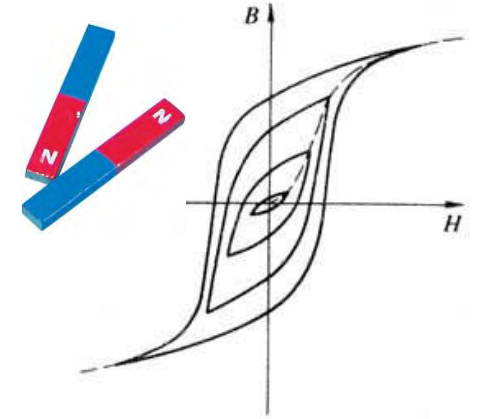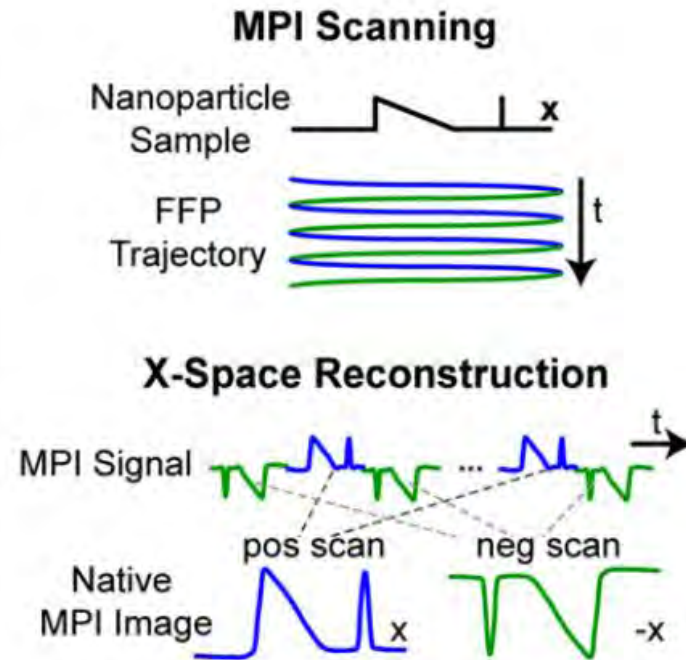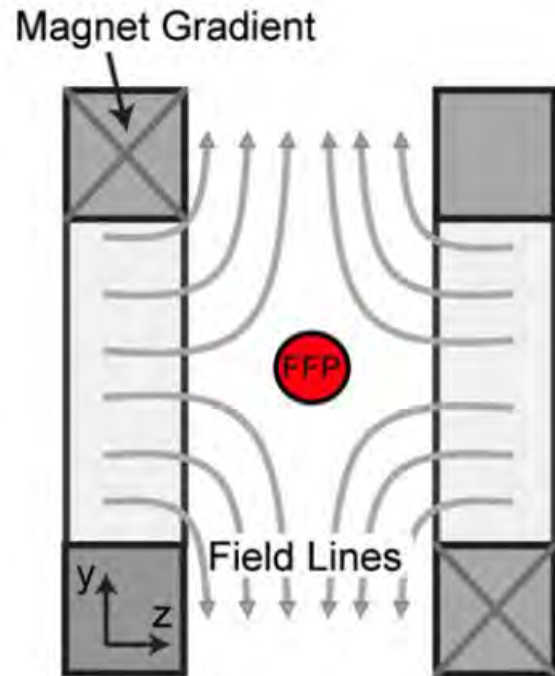
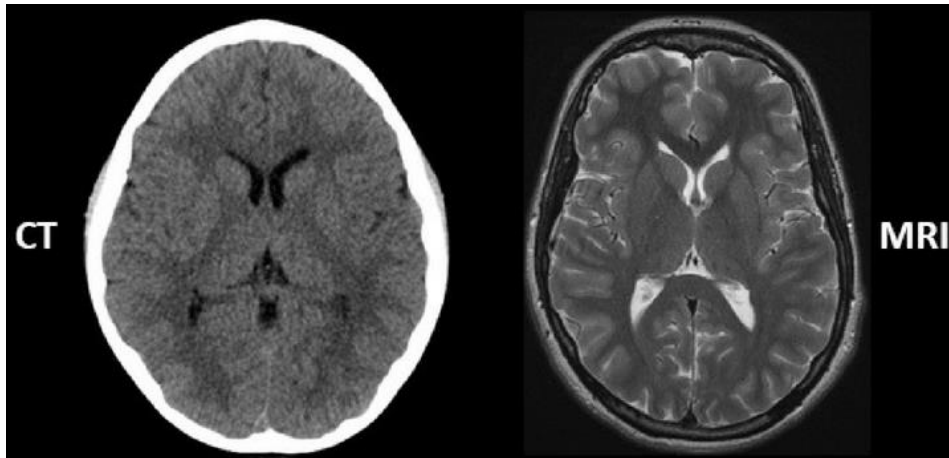Response at different magnetic field for Superparamagnetic nanoparticles

MPI principle

CT：X-ray
Sensitive to heavy elements:
Bones (Calcium)
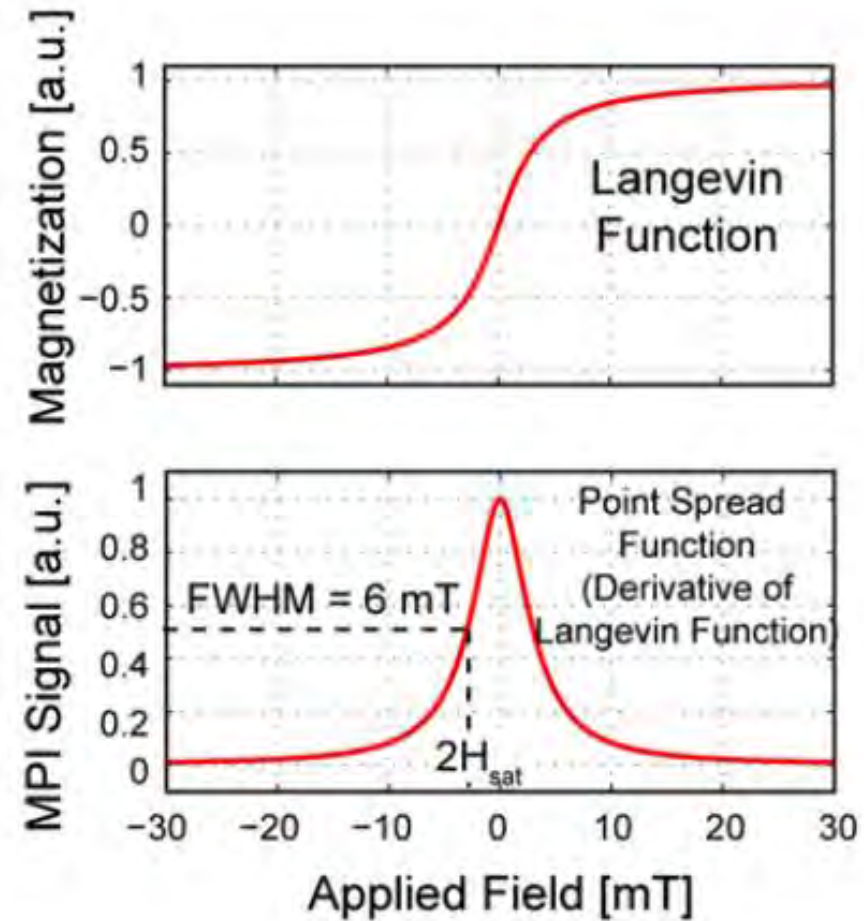
MPI: high resolution
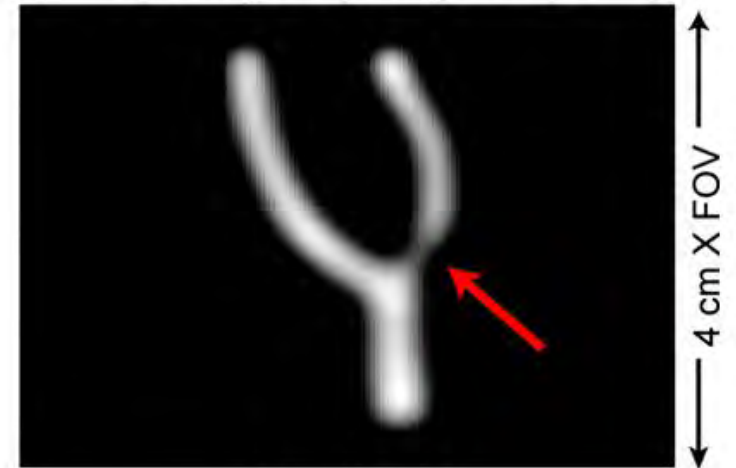

Carotid Phantom
no Stenosis

MPI image

CT

MRI
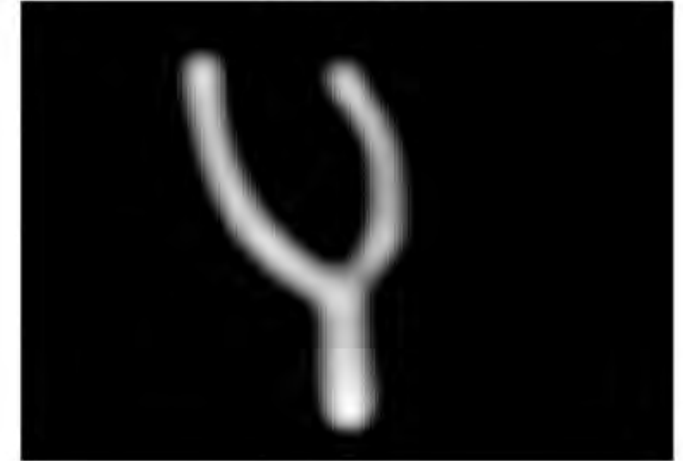
Carotid Phantom
with Stenosis

MPI image depicting stenosis

4 cm X FOV

6 cm Z FOV

a

b

MRI：Larmor procession
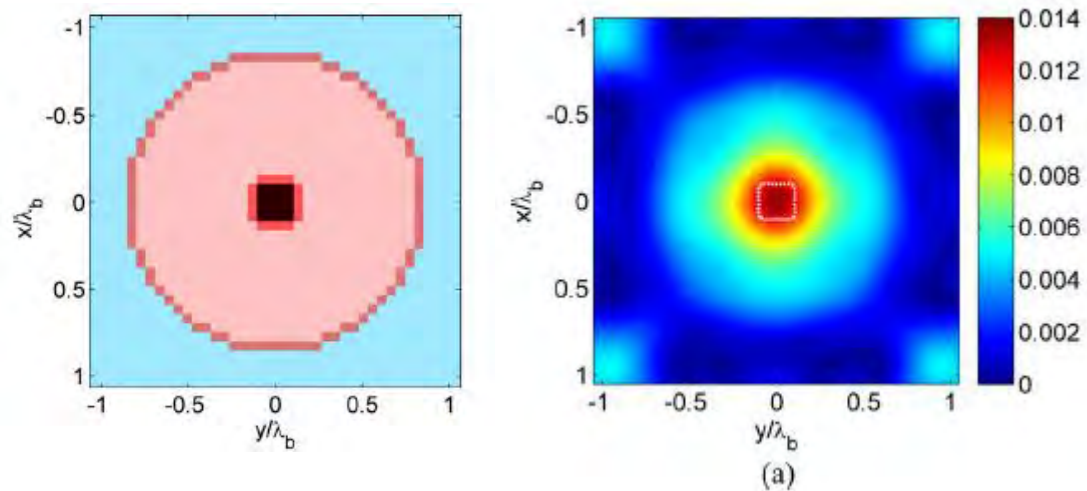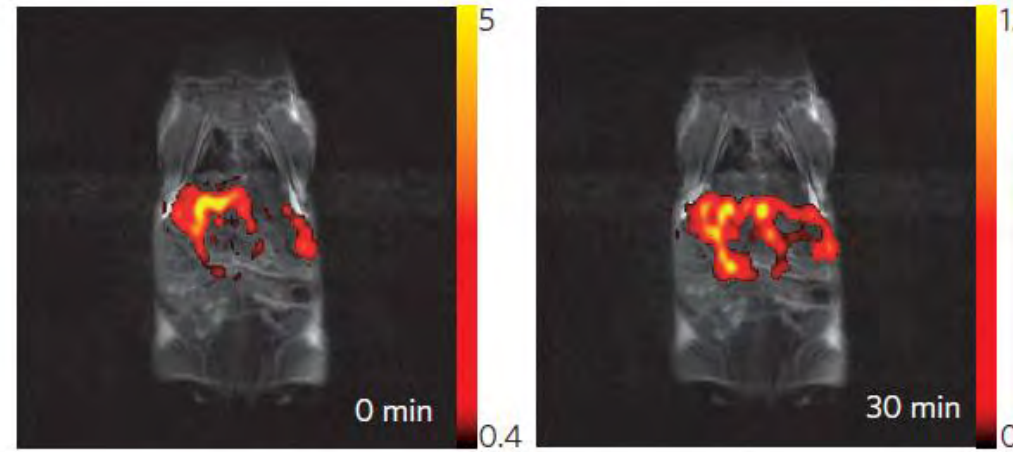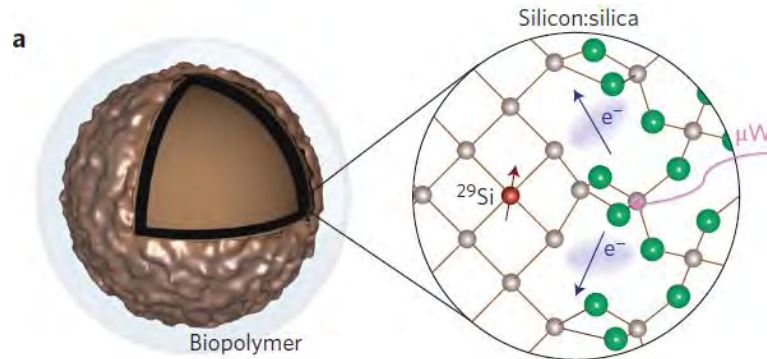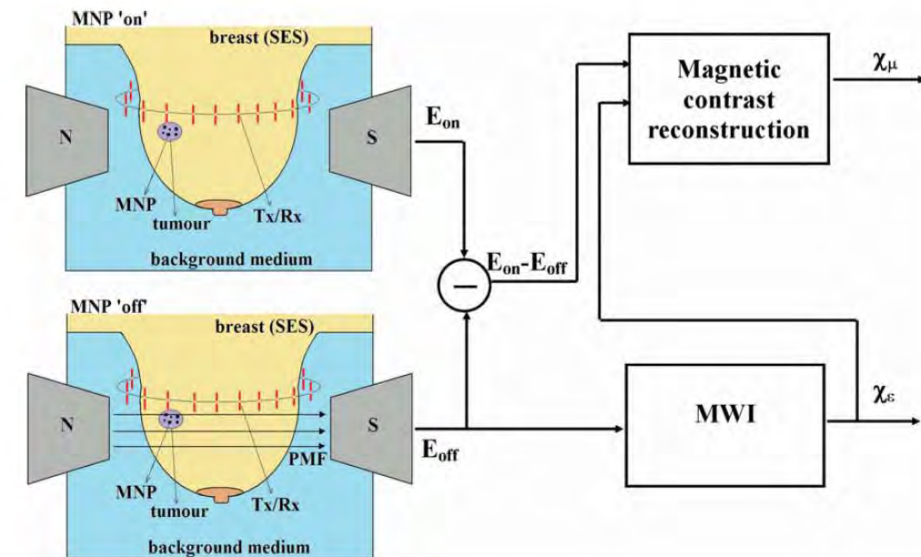Sensitive to light elements:
Soft tissue (Hydrogen)

ARTICLES

In vivo magnetic resonance imaging of hyperpolarized silicon particles

M. C. Cassidy[1], H. R. Chan[2], B. D. Ross[2], P. K. Bhattacharya[2,3] and C. M. Marcus[4,5]*

a

Silicon:silica
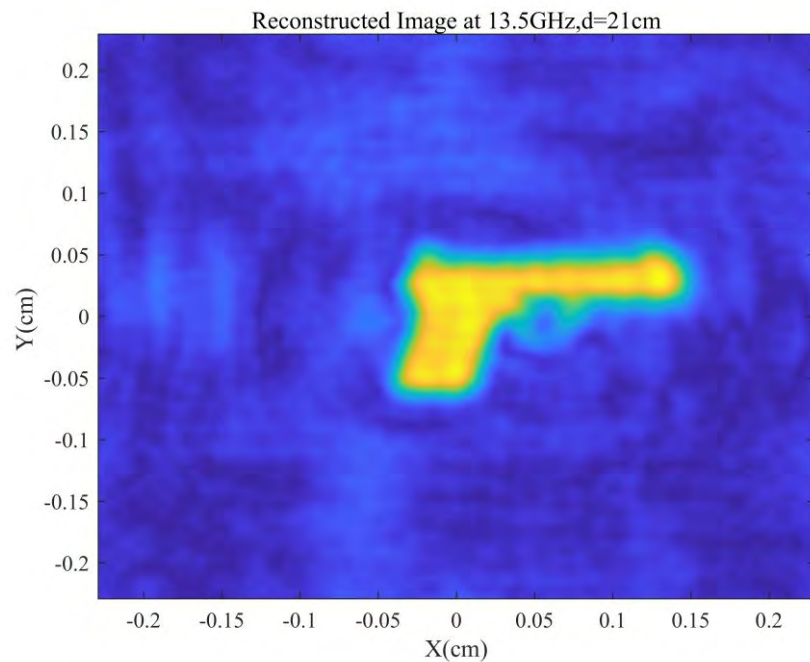
^{29}Si

e^-

μW

Biopolymer

0 min

30 min

Microwave Cancer Imaging Exploiting Magnetic Nanoparticles as Contrast Agent

Gennaro Bellizzi, Ovidio M. Bucci*, *Fellow, IEEE*, and Ilaria Catapano, *Member, IEEE*

MNP 'on'

breast (SES)

N

S

E_{on}

MNP

tumour

Tx/Rx

background medium

MNP 'off'

breast (SES)

N

S

E_{off}

PMF

MNP

tumour

Tx/Rx

background medium

$E_{on} - E_{off}$

Magnetic contrast reconstruction χ_μ

MWI χ_ε

χ_μ

x/λ_b

y/λ_b

x/λ_b

y/λ_b

(a)

What we can do for MPI?
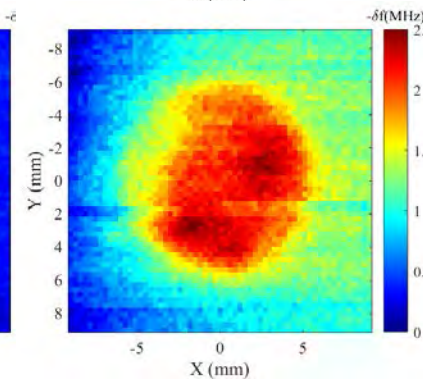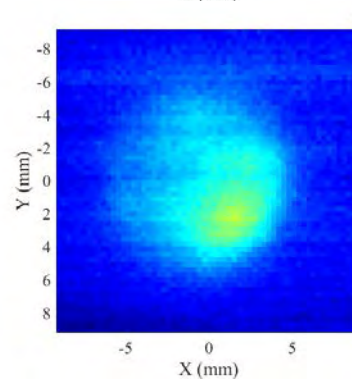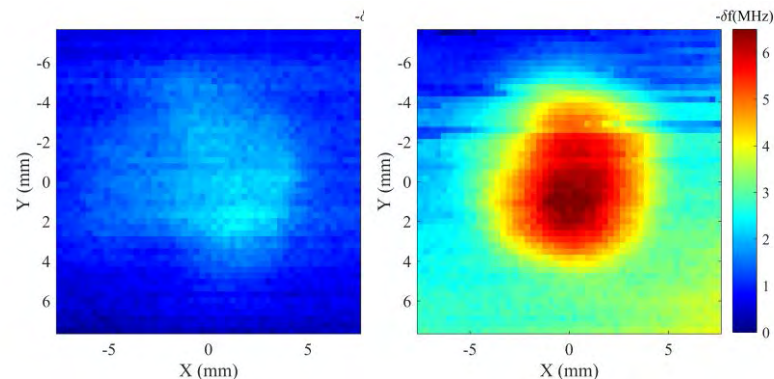

Reconstructed Image at 13.5GHz,d=21cm

Microwave imaging for nanoparticles

- Imaging without strong H field?
- Shallow in vivo imaging?

Without H field   With H field
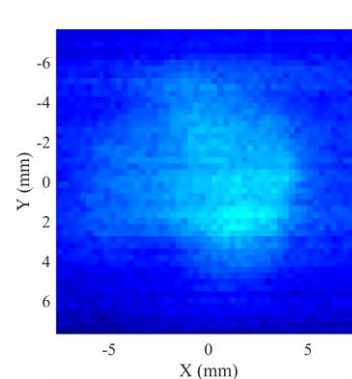
μ material near field imaging

- Repeatability problem
- Re-design the sensor