

A patient is lying on a table inside an MRI scanner. The patient is wearing a white cap and is positioned within the large, circular opening of the scanner. The background shows the interior of the scanner room, including a window and some equipment.

Magnetisk resonans imaging

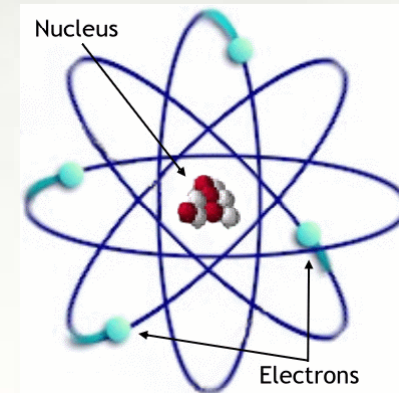
Basis sekvenser og metoder

Steffen Ringgaard

MR-centret, Aarhus Universitetshospital, Skejby

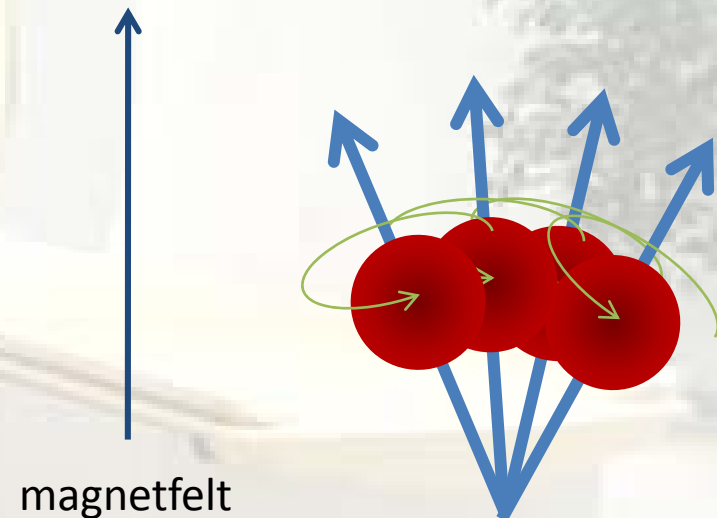
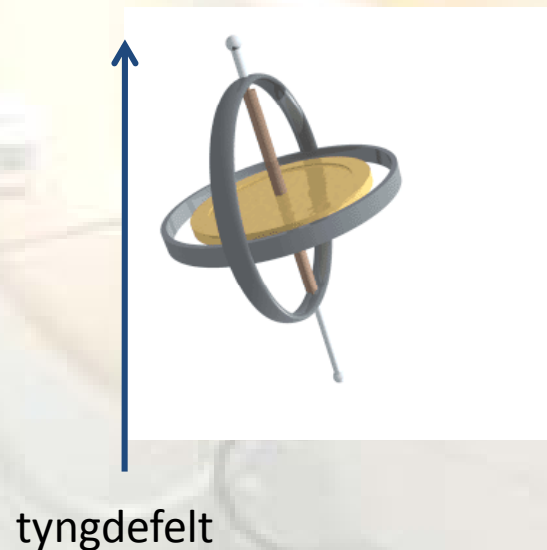
Kerne spin

- Visse atomkerner har spin
 - ^1H , ^{31}P , ^{13}C
- Kerner med spin har **magnetisk dipolmoment** og **impulsmoment**



Impulsmoment

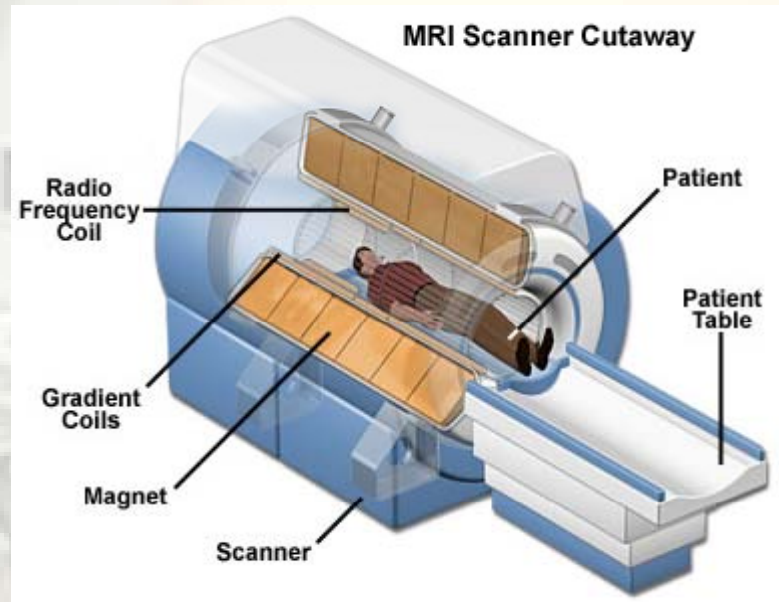
- Impulsmomentet skyldes rotation omkring en akse
- Impulsmoment i magnetfelt:
 - Analogt med snurretop i jordtyngdefelt
- Precession: langsom rotation omkring tyngde/magnet-akse



Precessionsfrekvens $f = \frac{\gamma}{2\pi} B_0$

Larmor's ligning

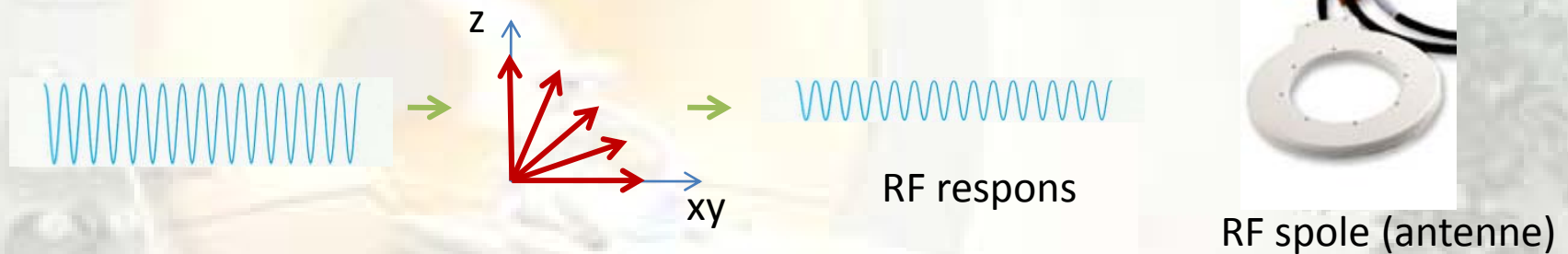
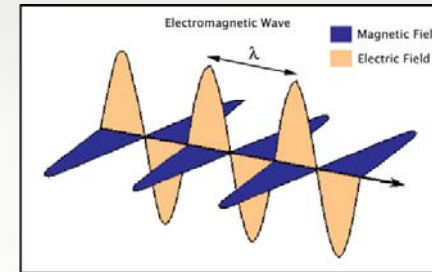
Superledende magnet



- Kølet med flydende helium, $-269\text{ }^{\circ}\text{C}$
- Feltet (og dermed strømmen) konstant i årevis

At kommunikere med spins

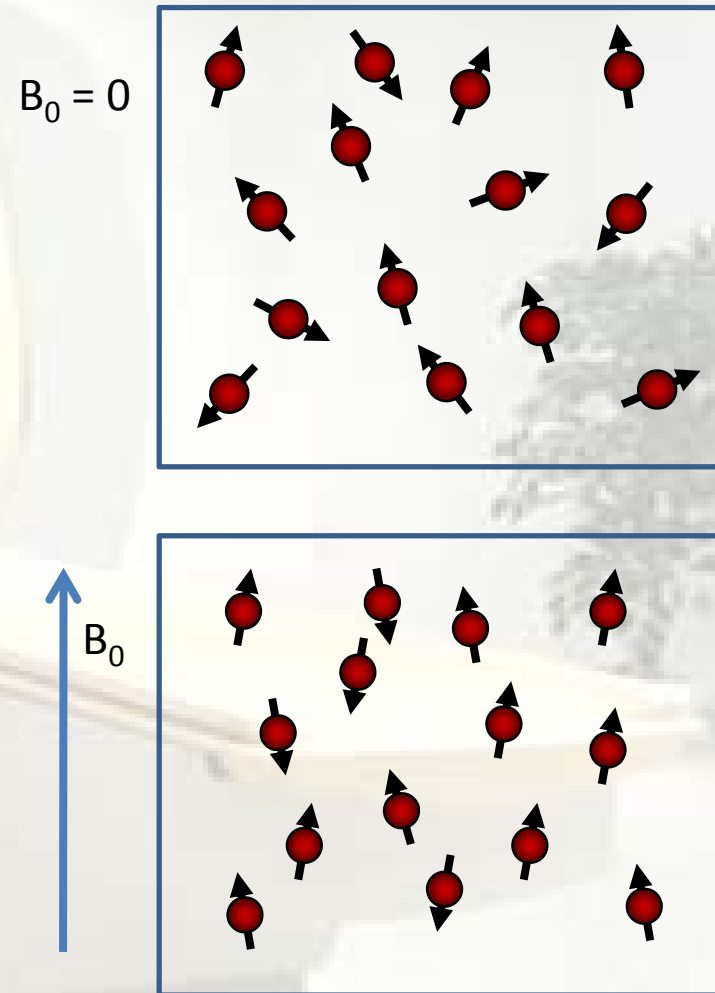
- Elektromagnetiske pulse med Larmor-frekvensen eksiterer magnetiseringen



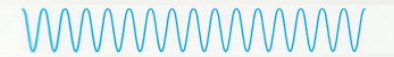
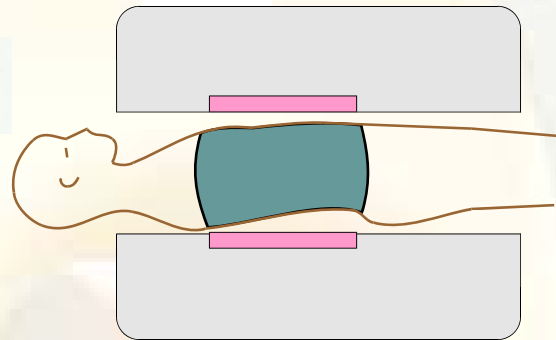
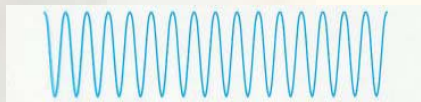
- Signalamplitude fra magnetisering mange gange mindre end eksitationssignalet

Enkelt spin -> magnetisering

- Spins i magnetfelt bliver ensrettet parallelt eller anti-parallelt
- Ca 5/1000000 (5 ppm) flere parallelle end anti-parallelle
- Størrelsen af magnetiseringen M er givet ved denne forskel
- Der kræves MANGE spins for at opnå tilstrækkeligt signal
- M øges med magnetfelt-styrke og reduceres med temperaturen

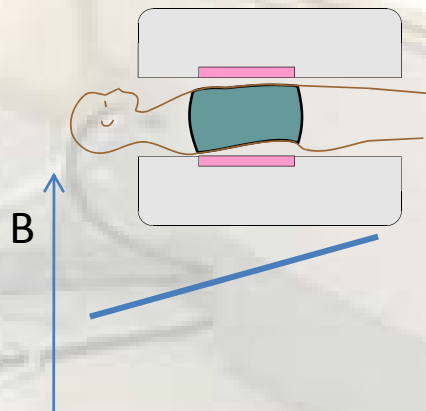


Positions-indkodning



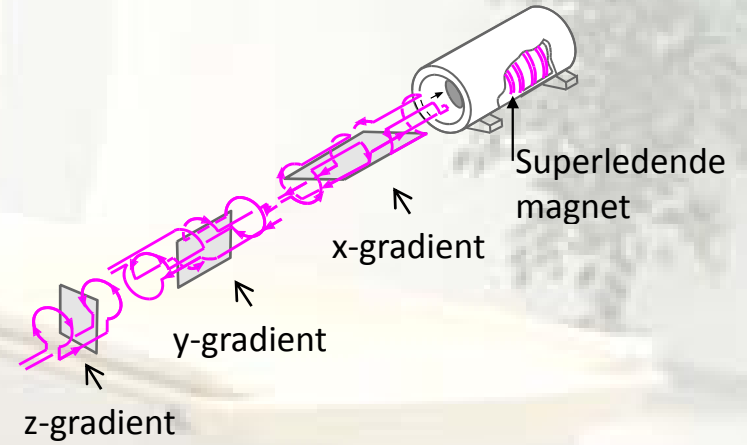
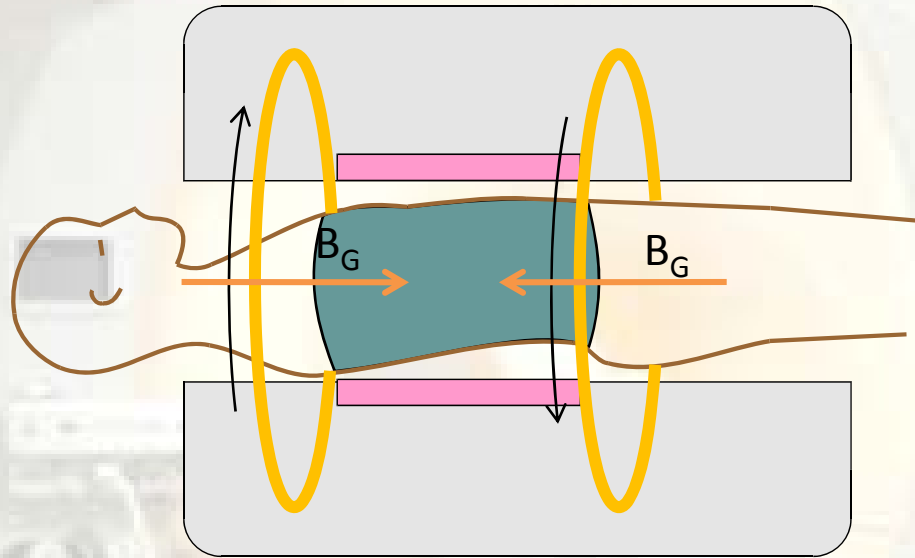
Samme frekvens
fra alt i skanner

- RF puls eksiterer alt i skanner
- Løsning: magnetiske gradient-felter

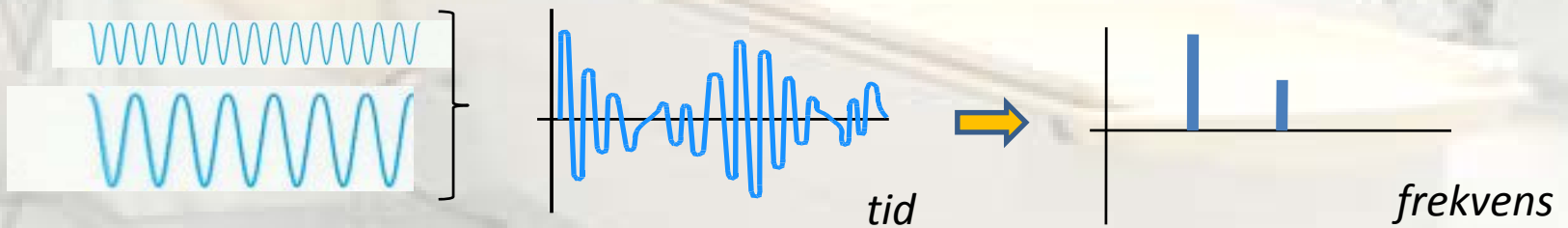
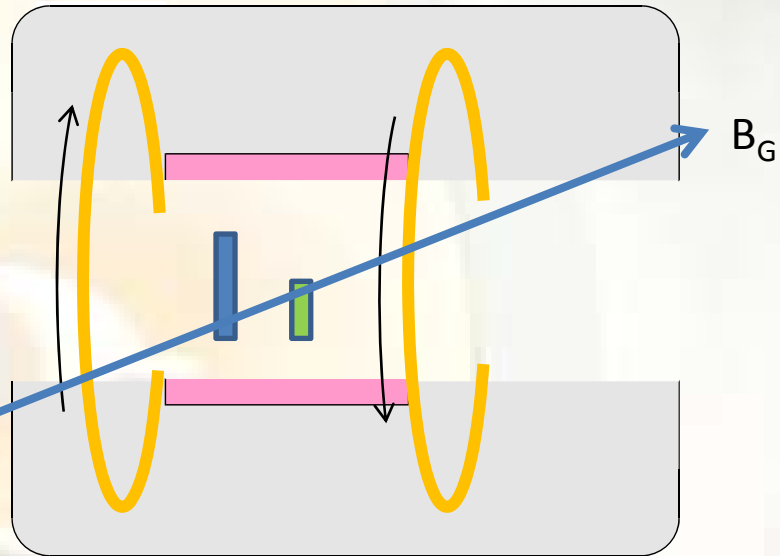


Frekvens afhængig
af position i skanner

Gradienten

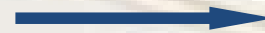
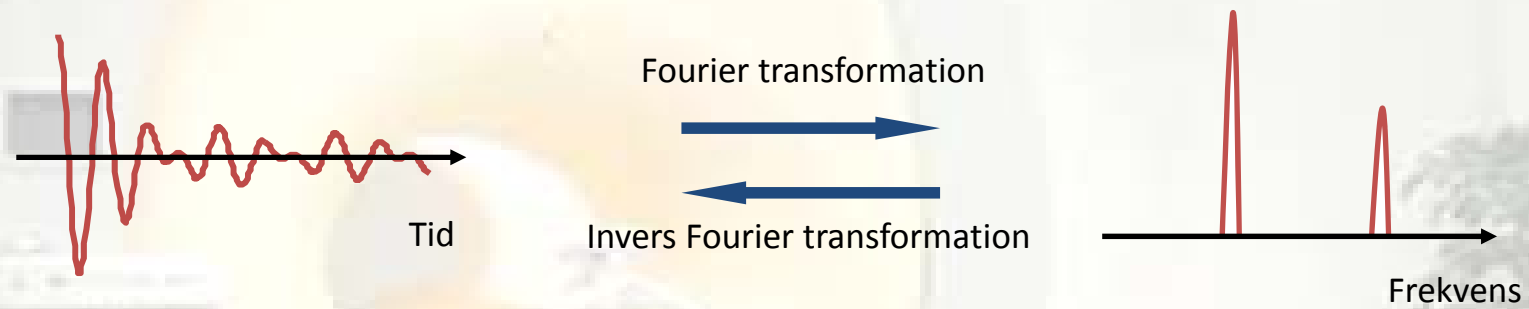


Frekvens indkodning



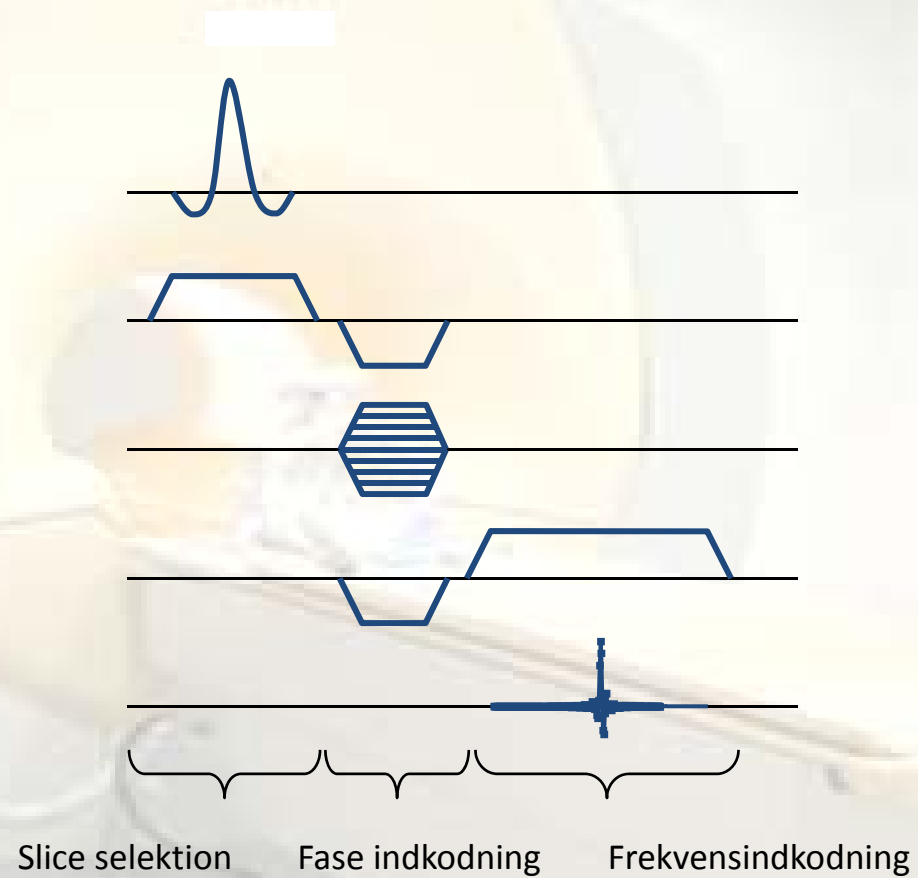
Fourier-transformation

Fouriertransformation

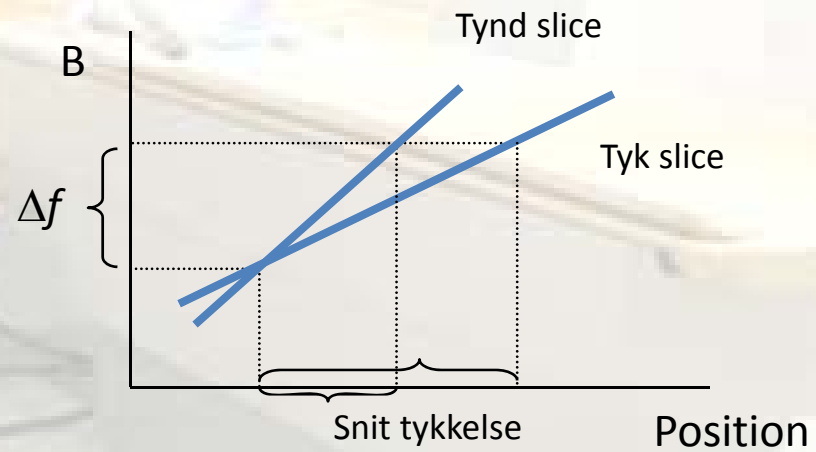
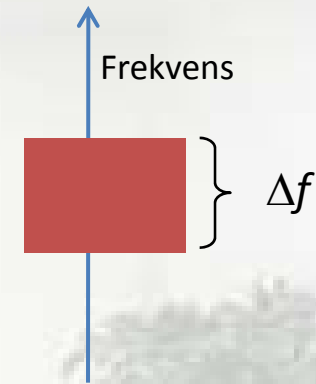
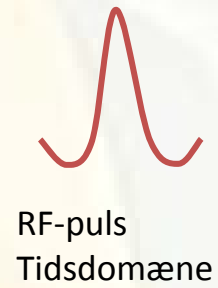
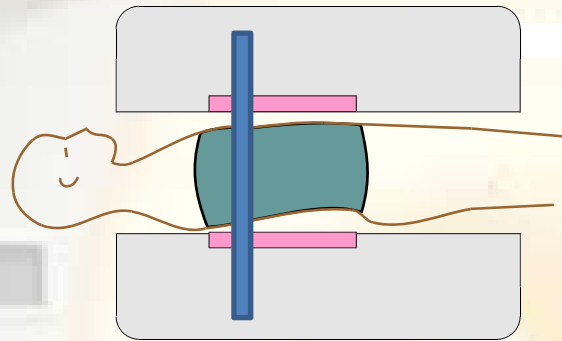


Puls sekvens

- Tre trin :

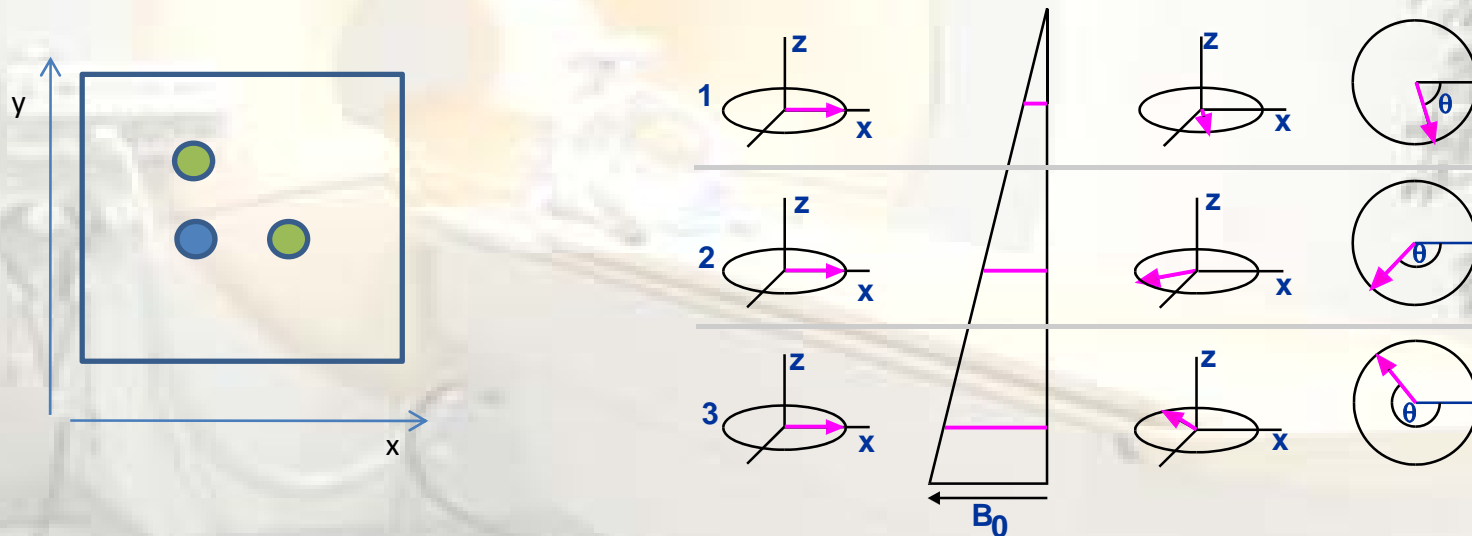


Slice selektion



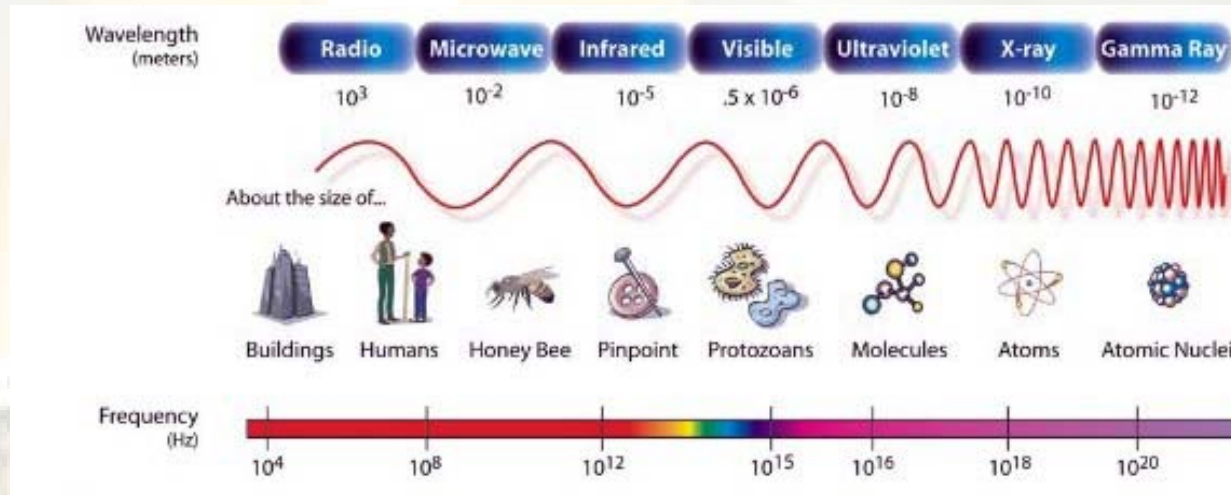
Fase-indkodning

- Frekvens-indkodning bruges til positions-bestemmelse i x-retning
- Positions-bestemmelse i y-retning laves med **fase-indkodning**



Bølgelængde og imaging

Optisk, røntgen imaging: Opløsning begrænset af bølgelængde



Magnetisk resonans

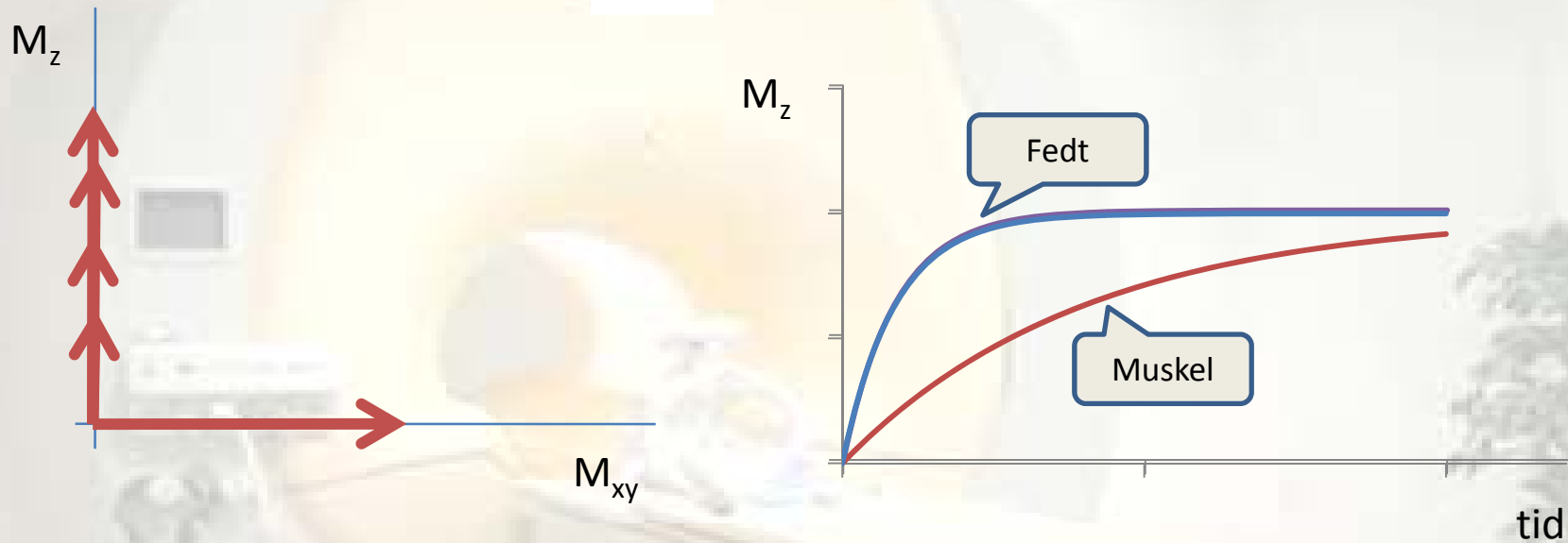
Optisk mikroskopi

Røntgen billedannelse

Magnetisk resonans imaging: Opløsning begrænset signal/støj forhold

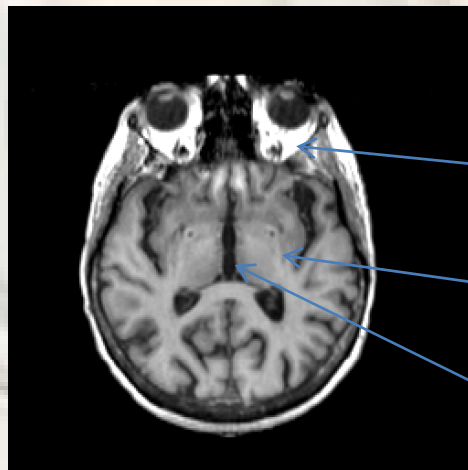
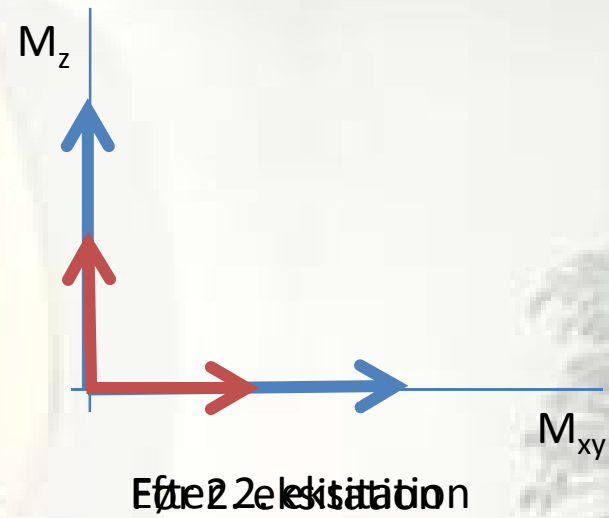
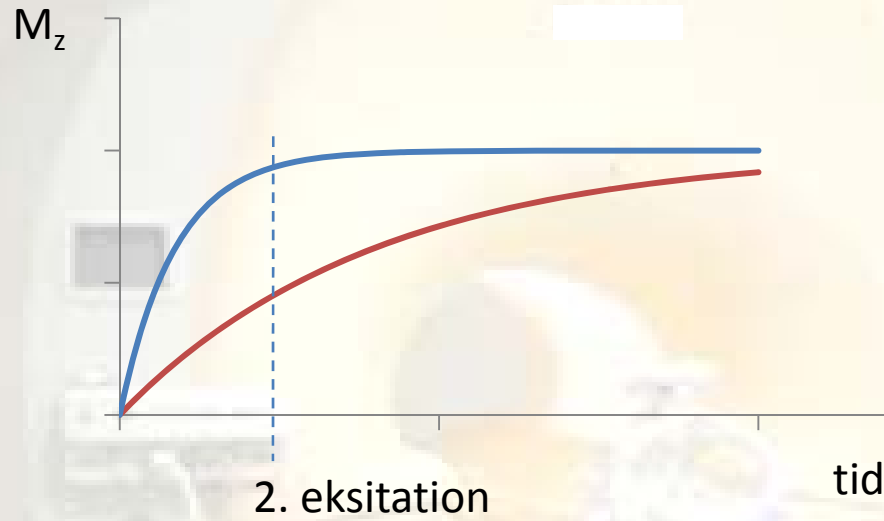
Kontrast i billederne

T_1 relaksation



- Hvordan kan dette udnyttes til kontrast-dannelse?

T₁ kontrast



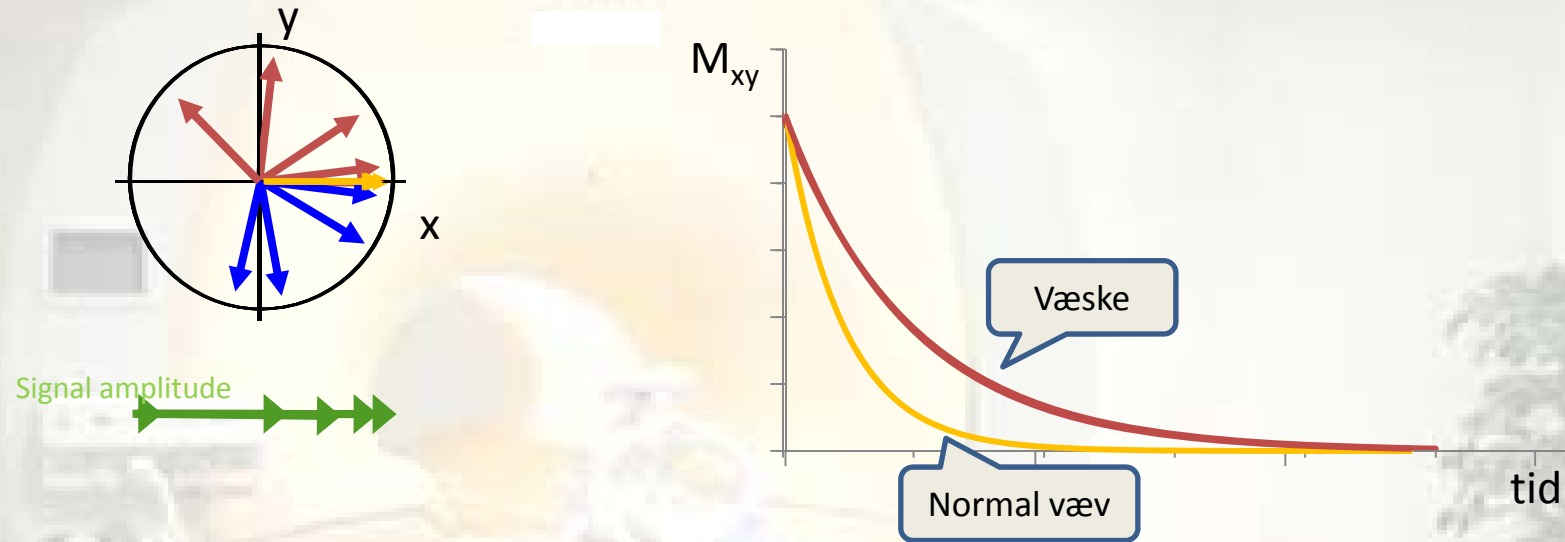
Fedt

Væv

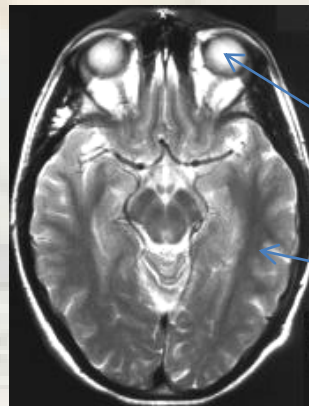
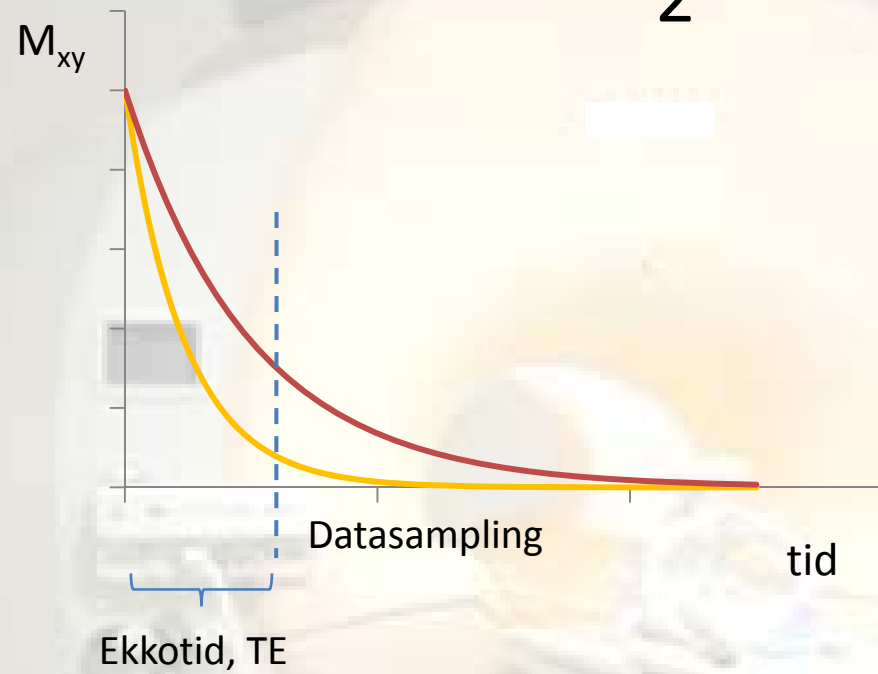
CSF

- Kort T₁: lyst
- Lang T₁: mørkt

T₂ relaxation



T₂ kontrast

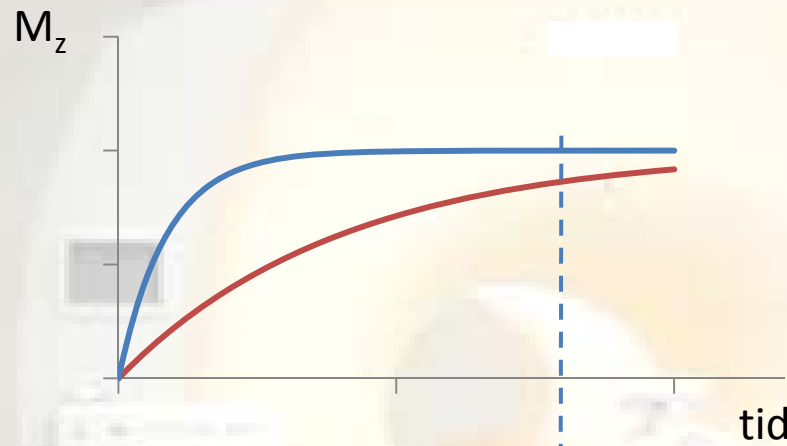


Væske

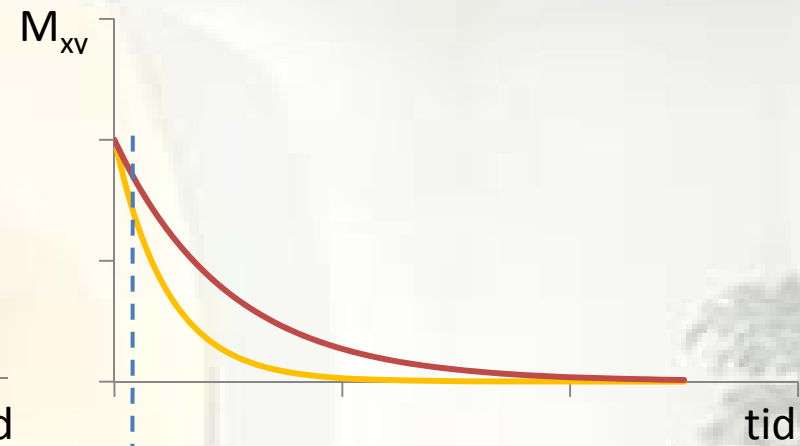
Væv

- Kort T₂: mørkt
- Lang T₂: lyst

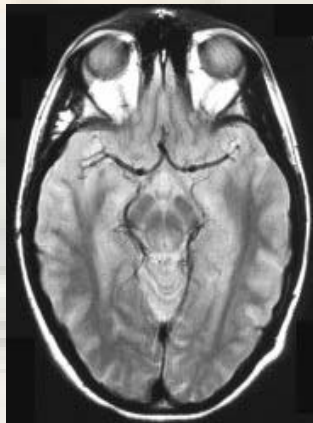
Proton vægtning



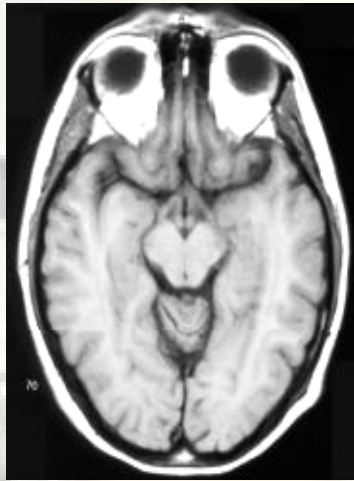
Lang TR
Reducere T_1 vægtning



Kort TE
Reducere T_2 vægtning

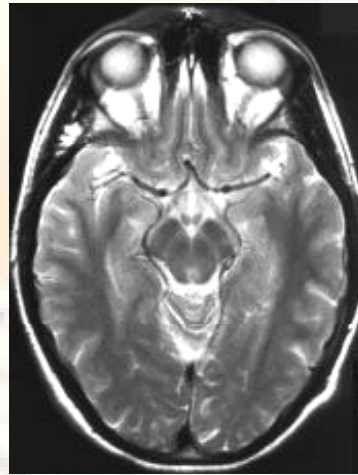


Kontrastvægtninger i MRI



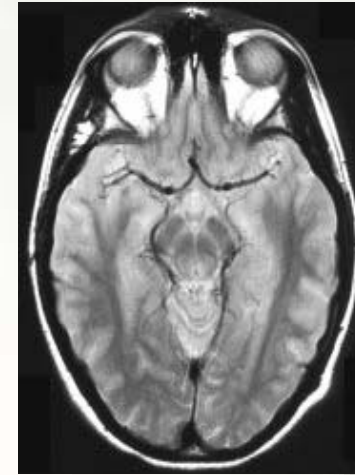
T1 vægtning

Kort/middel TR
Kort TE



T2 vægtning

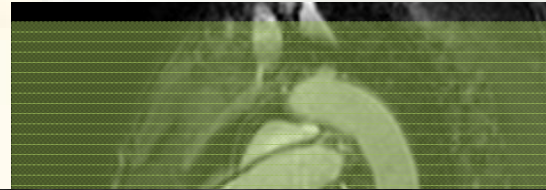
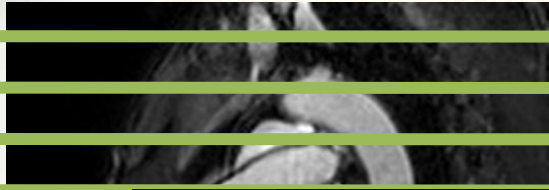
Lang TR
Lang TE



Proton vægtning

Lang TR
Kort TE

3D og 2D metoder



Multi-slice 2D

3D

Billed-eksempler

