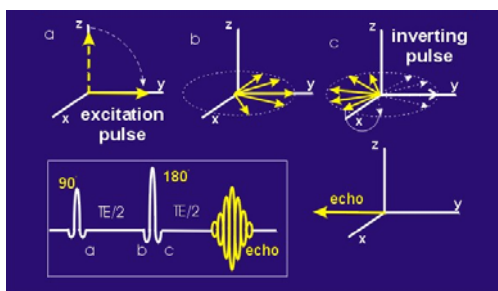
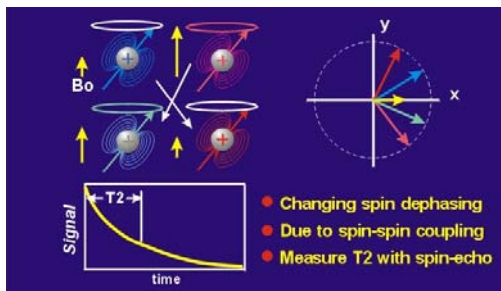
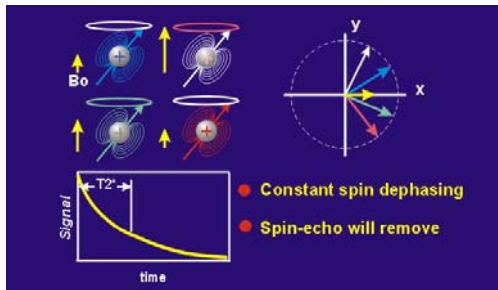
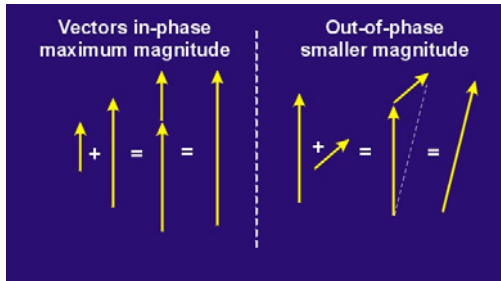


Seznam snímků a relevantní popis série popisu principu MR zobrazování včetně vztahu k jednotlivým videosekvencím

Obrázky a videa byly převzaty z anglického originálu Plewes, D.B.: The Animated Physics of MRI.



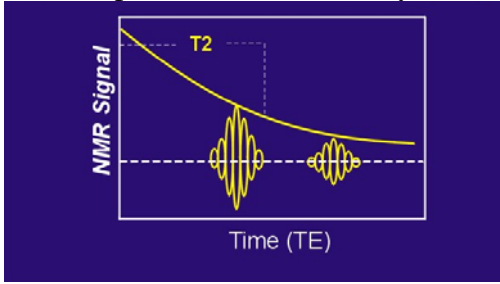
The spin echo 21

video 22 part 1 - The behavior of spin dephasing and RF pulses during the sequence

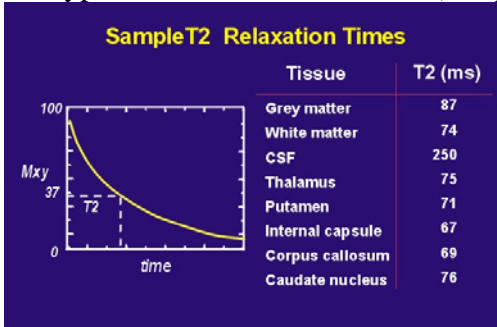
22 part 2 - NMR signal for different echo times TE

22 part 3 - Detailed view of the transverse magnetization components alone

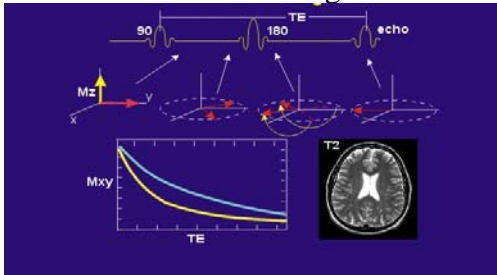
23 The spin echo - T2 summary (MNR signal vs. the time TE)



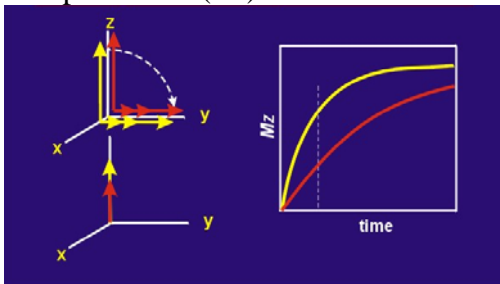
24 Typical T2 values in the head (sample T2 relaxation times)



25 T2 modulation of image contrast

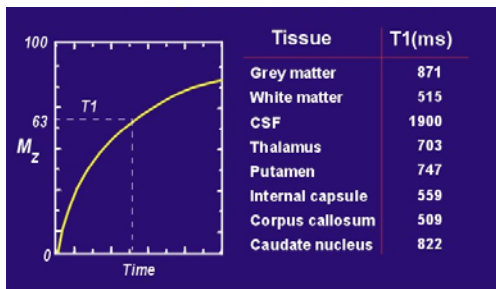


26 Spin-lattice (T1) relaxation

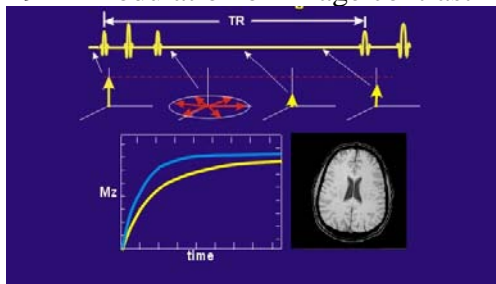


27 Spin-lattice (T1) relaxation - animation video 13

28 Spin-lattice relaxation values for various tissues (sample T1 relaxation times)



29 T1 modulation on image contrast



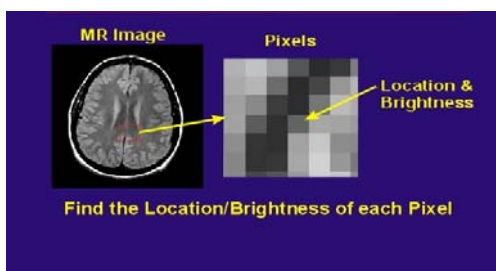
30 Summary of T1 and T2 relaxation (relaxation effects)

- T1 Relaxation**
- spin-lattice interactions
 - dissipation of energy
 - 200-2000 ms time constant
- T2 Relaxation**
- spin-spin interactions
 - loss of spin phase (order)
 - 25-250 ms time constant

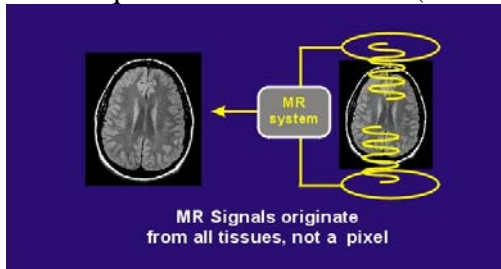
31 Overview of lecture on the physics of image formation (MR imaging)

- Image structure
- Fourier representation
- Magnetic field gradients
- Moving through K-space
- Collecting K-space data
- MRI sequence summary

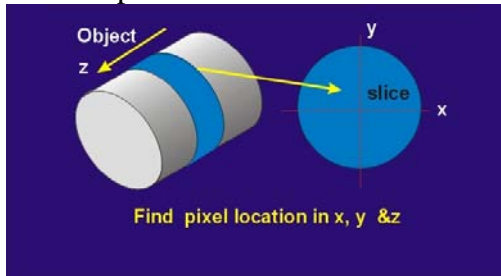
32 Structure of MR images



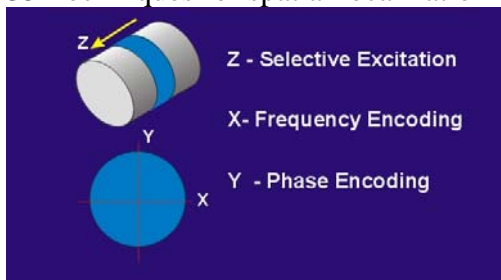
33 The question of localization (How do we localize the signal?)



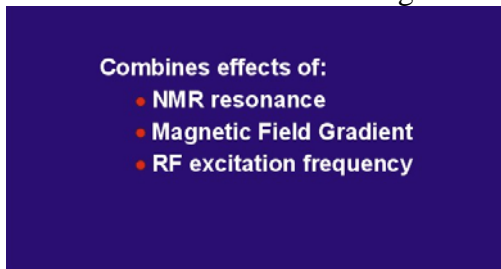
34 The spatial location task



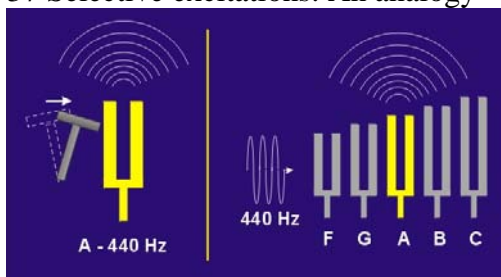
35 Techniques for spatial localization



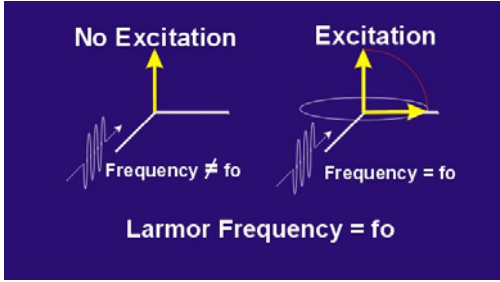
36 Selective excitation: The ingredients



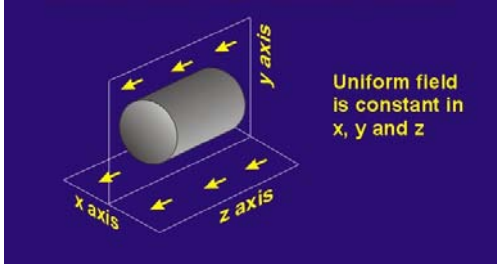
37 Selective excitations: An analogy - resonance



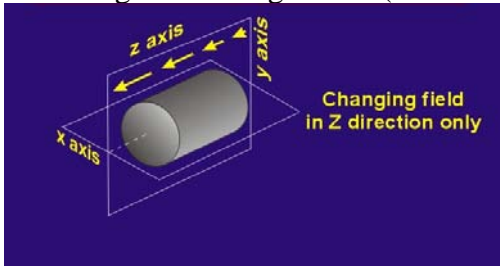
38 Selective excitations and NMR resonance



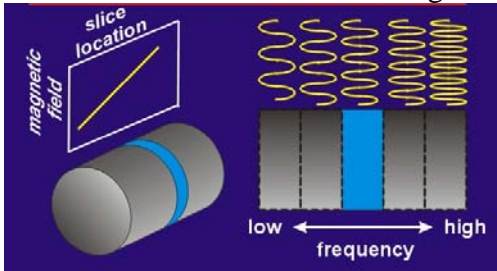
39 A uniform magnetic field (magnetic field gradients)



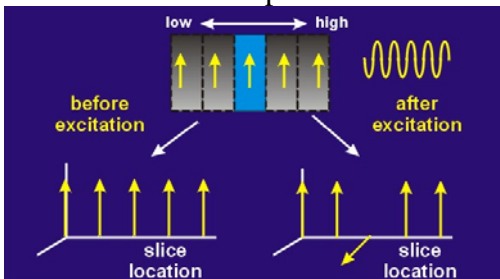
40 A magnetic field gradient (G_z - in Z direction)



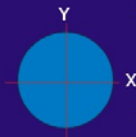
41 Selective excitation and a G_x gradient



42 The effect of RF pulses in selective excitation



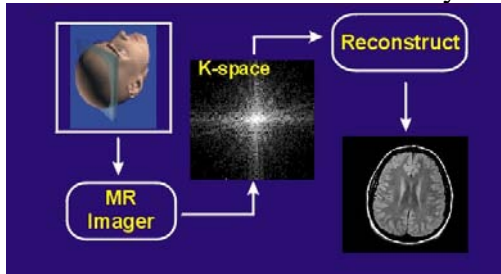
43 In plane localization



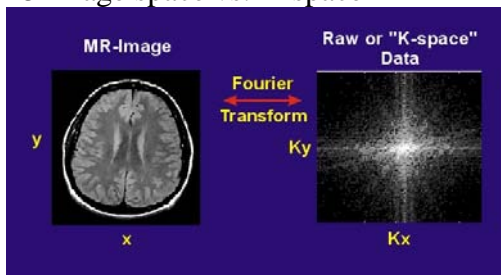
X - Frequency Encoding
Measures NMR signal in the presence of a gradient in the X direction

Y - Phase Encoding
Induces a different gradient to induce a phase twist in the Y direction.

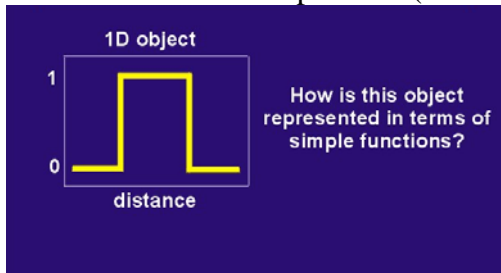
44 The relation between the MR system and image formation



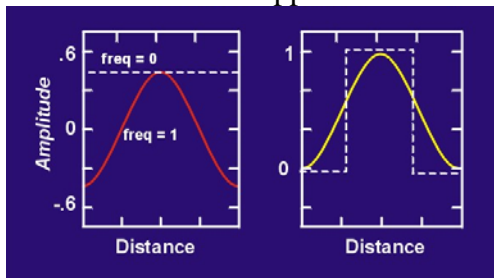
45 Image space vs. K-space



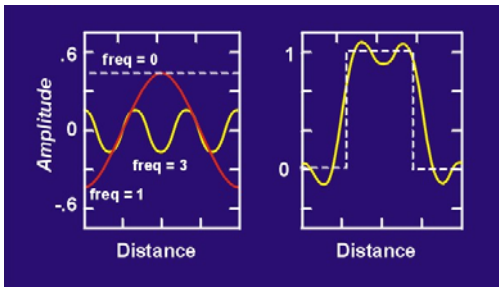
46 A one dimensional problem (Fourier transform)



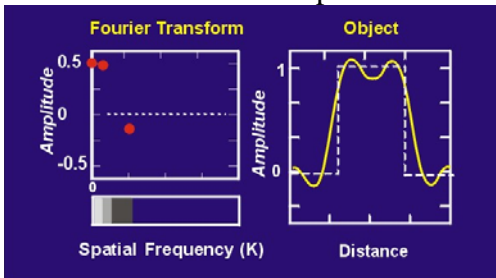
47 A crude Fourier approximation



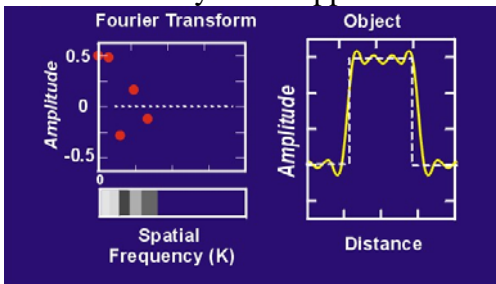
48 A better Fourier approximation



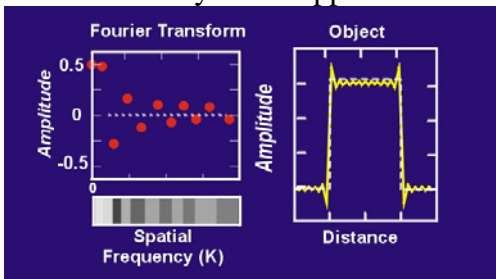
49 The definition of K-space



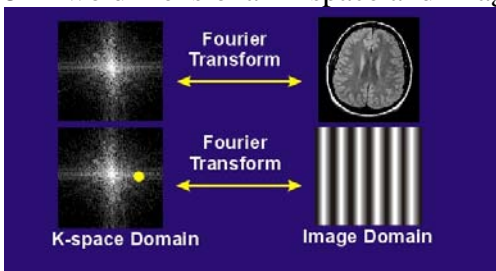
50 Successively better approximation



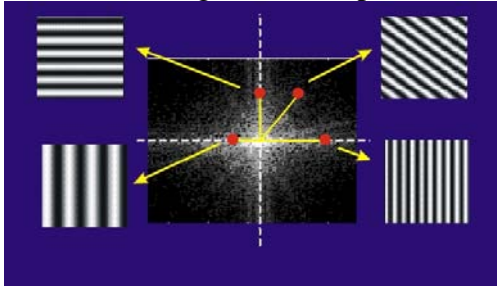
51 Successively better approximation



52 Two dimensional K-space and image space (space and image domains)



53 The meaning of various points on K-space (Fourier transform representation)

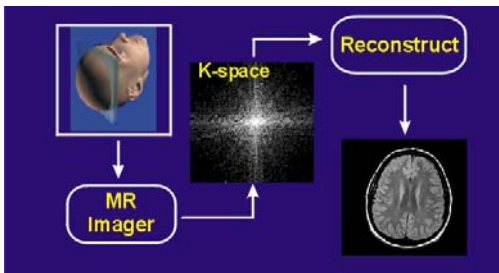


54 The question of How stripes are made in MRI ? (MR image formation)

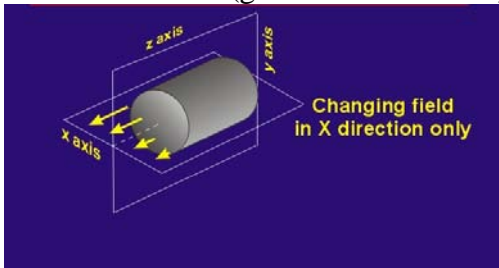
How does MR imaging make

- stripes?
- variable spatial frequency?
- variable orientation?

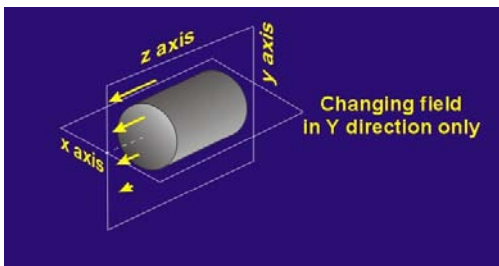
55 Return to the relation of the MR system and image formation



56 Gradient in X (gradient X direction)

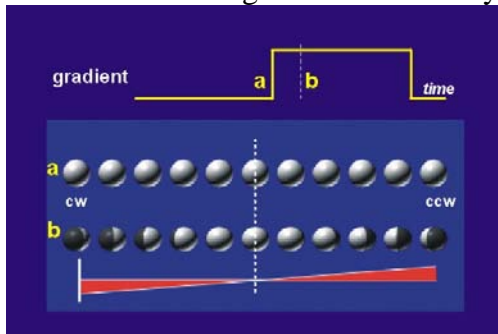


57 Gradient in Y (gradient Y direction)



58 An alternative representation for magnetization
video 14

59 The effect of a gradient on an array of magnetization balls



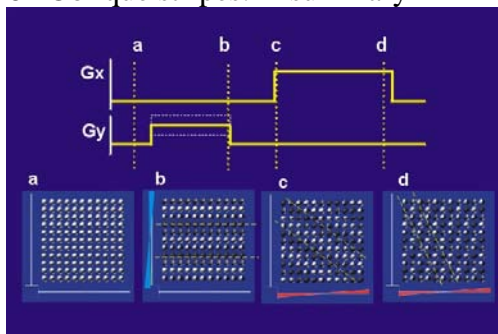
60 The effect of a gradient on an array of magnetization balls (animation)
video 15

61 Creating vertical stripes
video 16

62 Creating horizontal stripes
video 17

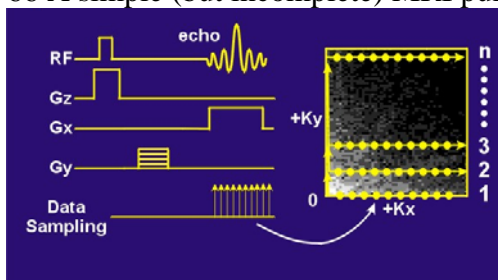
63 Creating blique stripes and K-space
video18

64 Oblique stripes: A summary

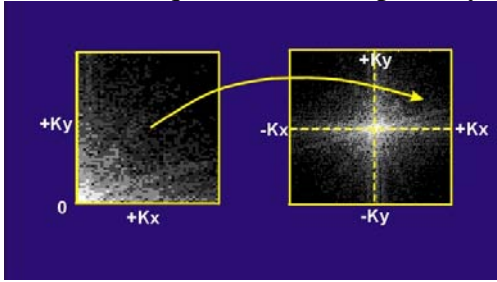


65 How does the MRI system measure the K-space signals?
video 19

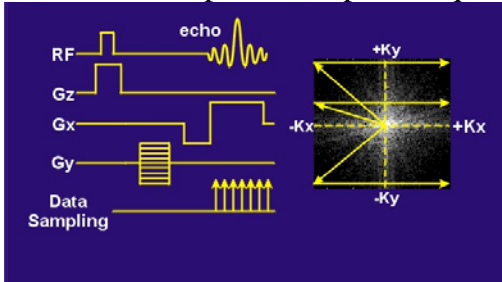
66 A simple (but incomplete) MRI pulse sequence



67 The four quadrants of K-space (symmetric 2D K-space)



68 A more complete MRI pulse sequence



69 Fourier reconstruction of K-space: part A video 20

70 Fourier reconstruction of K-space: part B video 21

71 Conclusion I (MR image formation)

- Spatial location by application of three orthogonal gradients
- **Selection excitation** defines slice location and width
- In-plane locations done by:
Frequency Encoding
Phase Encoding

72 Conclusion II (MR image formation)

Frequency Encoding

- Measures location in one direction
- MR signal measured with gradient on
- MR signal vs time measures the K-space data

73 Conclusion III (MR image formation)

- **Phase-encoding** defines Y position
- Incremented phase-encoding gradient generates K_y data
- Combined phase/frequency encoding defines all K-space data
- Requires many RF/gradient pulses to fill all K-space