

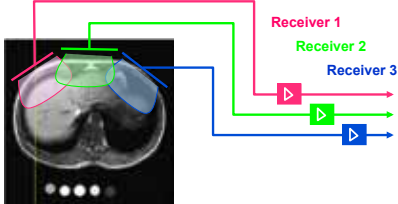

 Skåne University Hospital

Varför är parallel transmission intressant?

Sven Månsson, PhD
MR-fysiker
Skånes universitetssjukhus Malmö

What is parallel transmit?

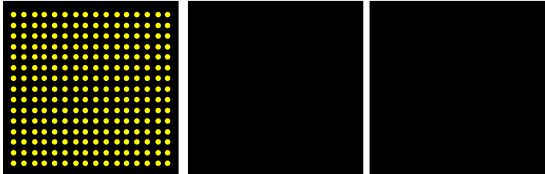
- We all use "parallel imaging" – what is that?
- One needs more than one RF-channel



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Parallel imaging speeds up acquisition

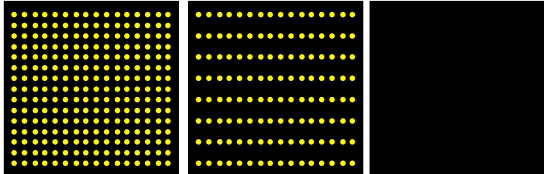
Take the data (in "k-space") needed for an image:



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Parallel imaging speeds up acquisition

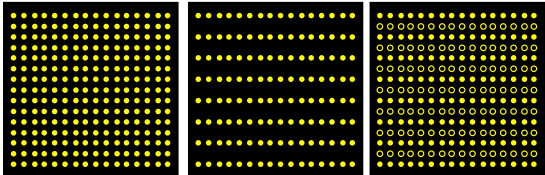
Acquire only half of the data
(scan time reduced by a factor of two):



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Parallel imaging speeds up acquisition

Use the parallel imaging reconstruction (SENSE, GRAPPA, etc) to fill out the missing data:

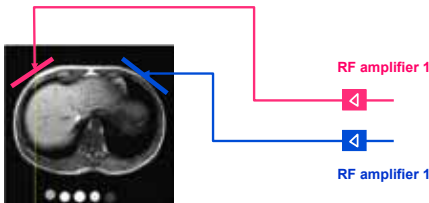


Can speed up 2-4 times, or more

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Parallel transmit is the same thing!

...but along the transmitter chain



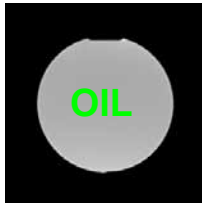
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This still doesn't explain anything...




Phantom images

3T, 240-mm phantom



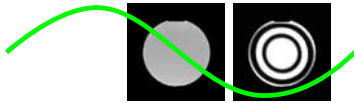
3T, 240-mm phantom



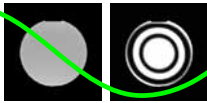
RF wavelength

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Phantom images



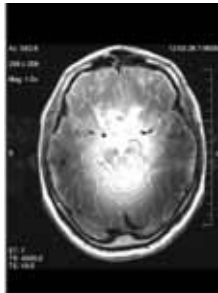
OIL WATER



The same effect as going from 3 → 0.7 T !

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Inhomogenous RF-excitation at high magnetic fields: 7 T




Courtesy of Prof. N. J. Shah
FZ Jülich

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Problems with an inhomogenous RF-field

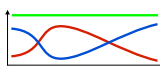
- Different image intensities in different locations
- Local heating (SAR exposure)
- Problematic at 3T, critical at 7T

• Solution: Parallel transmit



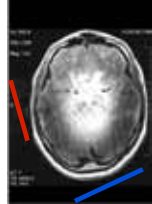
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RF-shimming with multiple amplifiers and coils



...may be counterbalanced by another coil with different phase and geometry

Inhomogenous RF-profile from one coil...



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Transmit (B_1) homogeneity:
simultaneous excitation with multiple transmit coils

Homogenization of the transmit field

single coil 8 Tx-coils, single RF channel 8 Tx-coils, independent channels

MGH, Boston

Courtesy of Prof. N. J. Shah
FZ Jülich

Vahedipour, Shah, Stöcker; FZ Jülich

Application: multi-dimensional RF-excitation

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2D RF excitation

Slice gradient

Typically, a spiral-shaped slice gradient is used

RF

The RF-pulse is the 2D FFT of the desired 2D excitation profile

Resulting excitation

Ullman et al
ISMRM 2005

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2D RF excitation
Acceleration with parallel transmit

The excitation process is slow, tens of ms

The process can be sped up with parallel transmit, in analogy with parallel receive (SENSE, GRAPPA, etc)

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Transmit (B_1) homogeneity:
simultaneous excitation with multiple transmit coils

I. Homogenization of the transmit field

single coil 8 Tx-coils, single RF channel 8 Tx-coils, independent channels

MGH, Boston

II. Zoomed MRI with 3D Gradient-Encoded RF pulses
(Generalization of the slice selection process)

→ High resolution ROI imaging in short scan times!

Courtesy of Prof. N. J. Shah
FZ Jülich

Vahedipour, Shah, Stöcker; FZ Jülich

New results:
parallel transmit / selective excitation

Single channel: $P_{\text{des}} = P_0 \sum_{n=0}^N B_1(t_n) e^{ik(t_n) \cdot x}$

Multi channel: $P_{\text{des}}(x) = \sum_{c=1}^C B_{1,c} F(S_c(x))$

True 3D selective pulses:

- Solving a HUGE linear system
- Using FZJ supercomputers
- Examples below need 65 GB of RAM

Simulation result: (JEMRIS)

- 8 Tx channels
- 3D checkerboard

4 Tesla result:

- 8 Tx channel pseudo set up
- 3D selective excitation of a homogenous box

Courtesy of Prof. N. J. Shah
FZ Jülich

Conclusion

- Parallel transmit gives
 - Homogenous excitation
 - Improved SAR handling (avoid local heating)
- Useful at 3T, critical at 7T
- Can speed up spatially complex RF-excitations in 2 or 3 dimensions

THANK YOU!

