

SLOVENSKÁ AKADÉMIA VIED

ÚSTAV MERANIA

INSTITUTE OF MEASUREMENT SCIENCE

70

ROKOV VEDECKÝCH A VÝSKUMNÝCH AKTIVÍT

1953 – 2023



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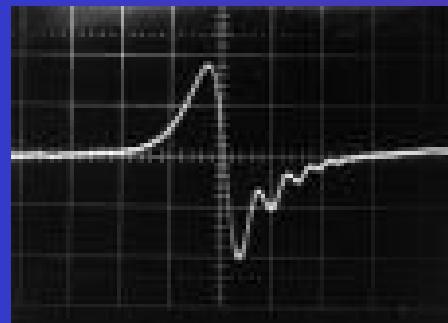
70

Oddelenie zobrazovacích metód

1953 – 2023

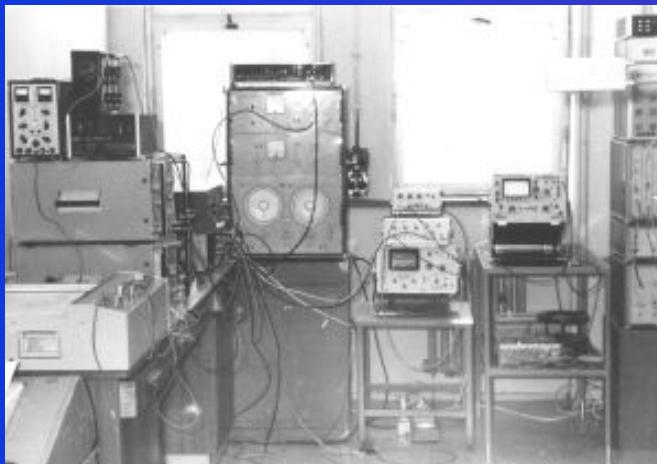


Významné výsledky



Prvý NMR signál

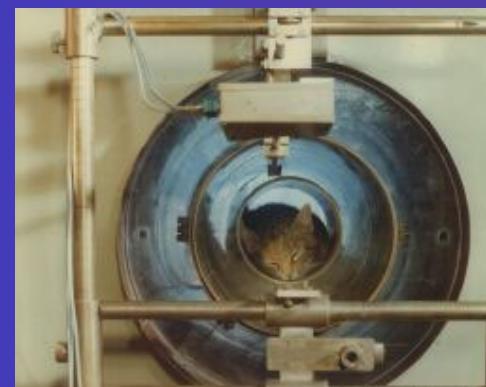
Prvý NMR experiment 1980



Experimentálny tomograf 1982 0.07 Tesla



Panely analógových modulov



Zobrazovanie malých vzoriek.



*Experimentálne zariadenie na tomografické
zobrazovanie biologických štruktúr
pomocou magnetickej rezonancie TMR-86,
(I. Frollo a kol. 1981-86)*



*„Cena SAV“ za rok 1987 za prácu „Príspevok
k rozvoju tomografických zobrazovacích metód na
princípe nukleárnej magnetickej rezonancie“
kolektívu riešiteľov.*

Celotelový tomograf 0.1 Tesla



1992





Celotelový tomograf
0.1 Tesla

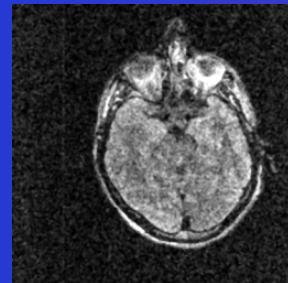
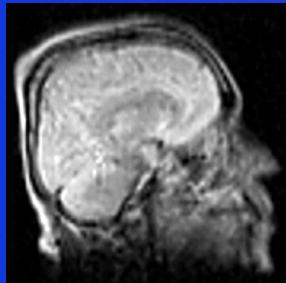


Panel analogových modulov

Riadiaca konzola S.M.I.S.

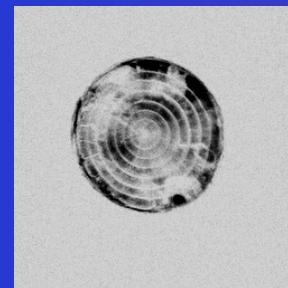
Sada vf. snímačov na zobrazovanie
hlavy a malých vzoriek.



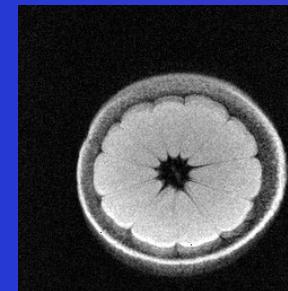
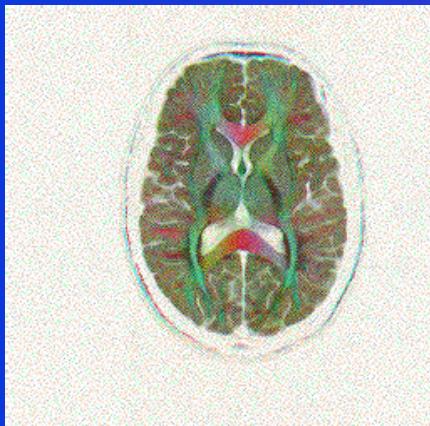


Sagitálne a transverzálne obrazy ľudskej hlavy, 128 x 128

FOV 320x320 mm, $T_E = 50$ ms,
 $T_r = 1750$ mm, 4 akumul.



Transverzálne rezy dreviny,
 $D=76$ mm, 256x256
Spin Echo 2DFT



Zobrazenie botanickej vzorky
(citrón), hrúbka 7 mm
 $D=86$ mm, 256x256 bodov, Spin
Echo 2DFT, 18 akumul.

Difúzne zobrazovanie na báze NMR
orientované na anizotrópiu ľudského mozgu

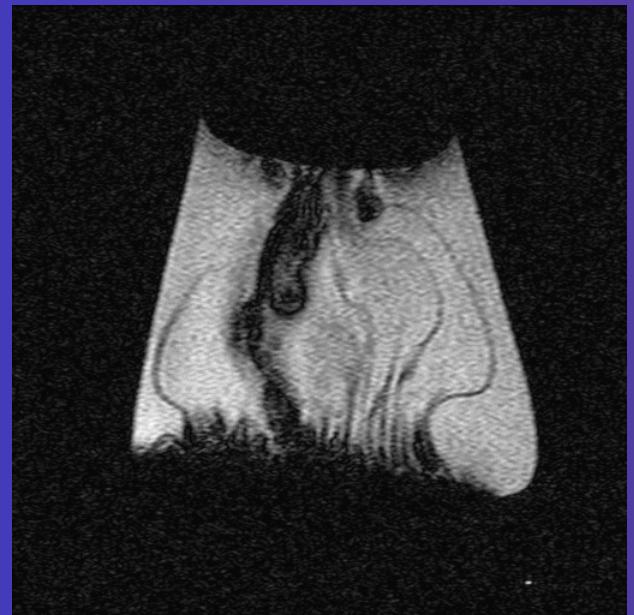
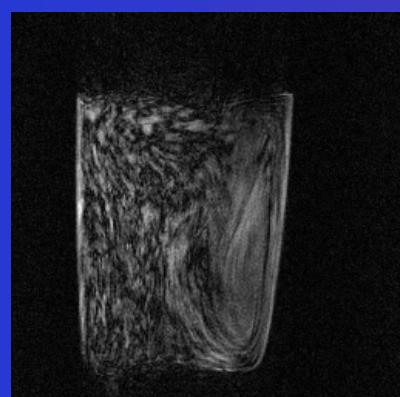
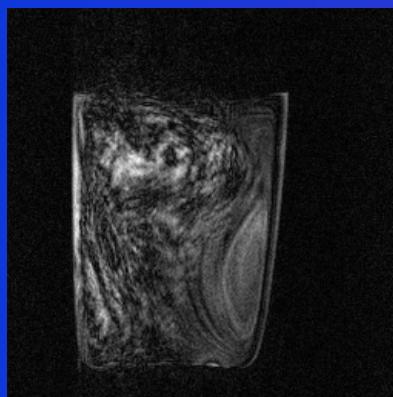
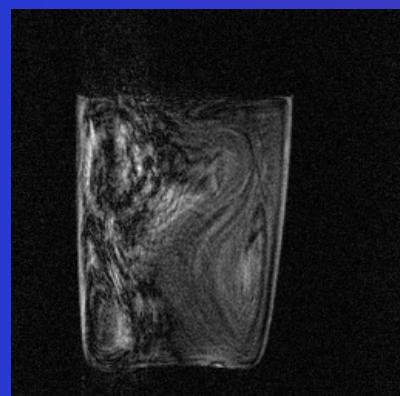
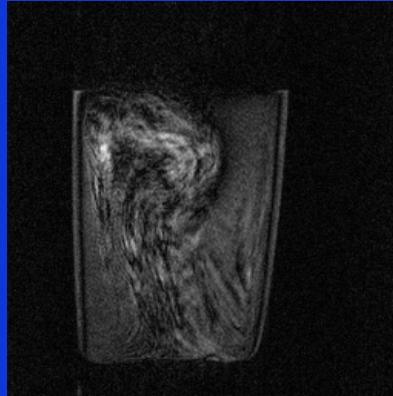


Metódy a výpočtové algoritmy na optimalizovaný návrhov zdrojov magnetických polí

- metóda vyšetrovania chemického posuvu pri *zobrazovaní ľudskej pokožky*
- zobrazovanie *difúzie* s vysokým rozlíšením
- projekčno-rekonštrukčná MR *spektroskopia*
- zobrazovanie zložiek *kostnej drene*
- výskum *waveletovej transformácie* v spracovaní signálov v NMR tomografii.



Imaging of magnetic nanoparticles - diffusion in water



Magnetic particles movement due to the Brownian motion in the liquid

Time differences between images: 120 seconds

EXPERIMENTAL RESULTS

NMR imager ESAOTE – Opera



MRI was realized on
small-scale NMR Imager
with permanent
magnet 0.2 T

Small-scale NMR Imager with permanent magnet 0.2 T

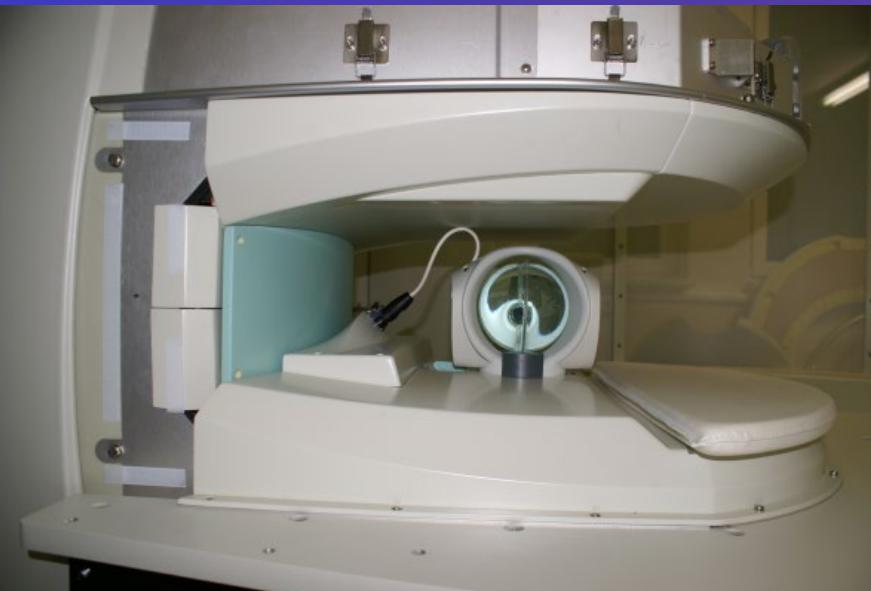
Producer:

The Esaote Group, Genoa,

Via A. Siffredi, 58, 16153 Genova, ITALY

Delivered by: WEGA s.r.o.

Instrument produced by company ESAOTE for research purposes

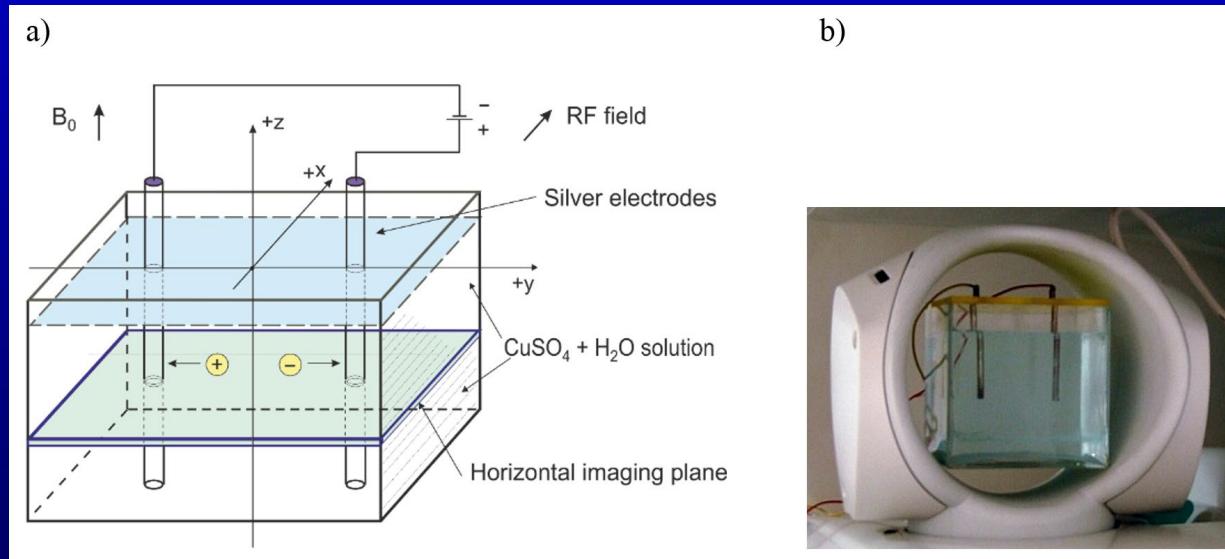


NMR imager ESAOTE – Opera, control console





Experimental measurement arrangement for ions flow



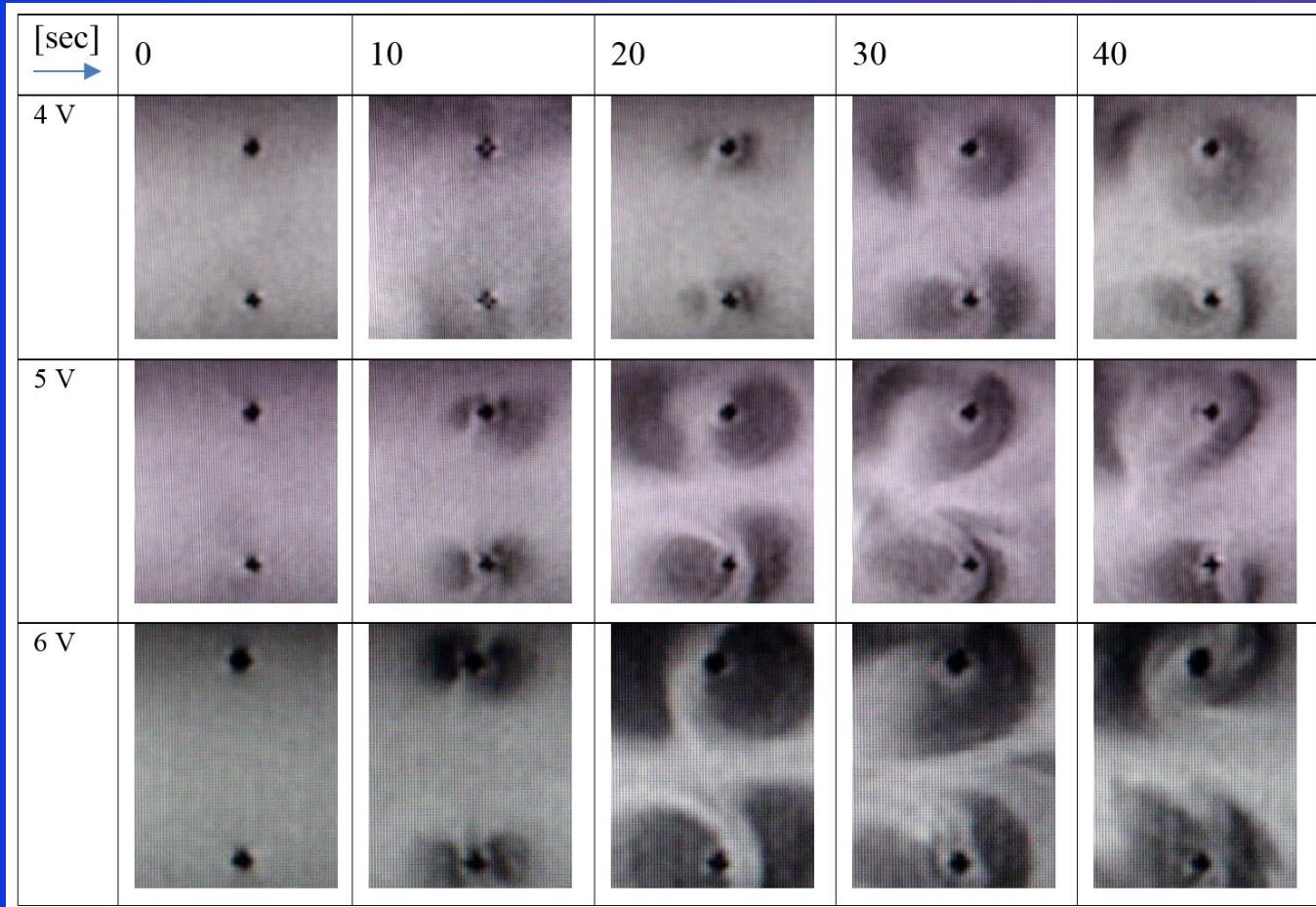
- a) A glass container, filled with watery solution of the copper sulfate.
- b) Measuring vessel with silver electrodes placed into the radiofrequency coil of the magnetic resonance imager.

Watery solution of the copper sulfate as a salt of copper:

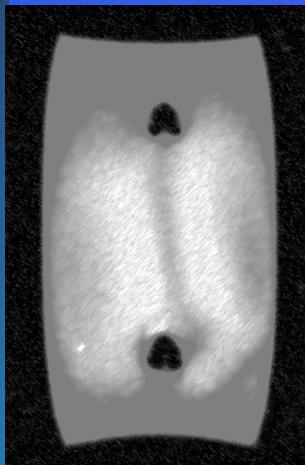


EXPERIMENTAL RESULTS

Horizontal imaging of ions flow in [x, y] plane



Coronal imaging using 3 electrical parameters for the electrodes



Enhanced contrast

Starting image, 0 V

3 sec.

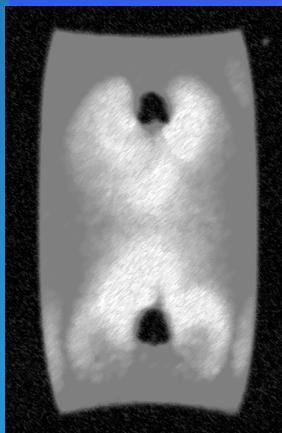
30 sec.

3 sec.

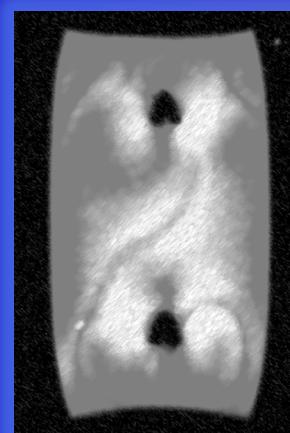
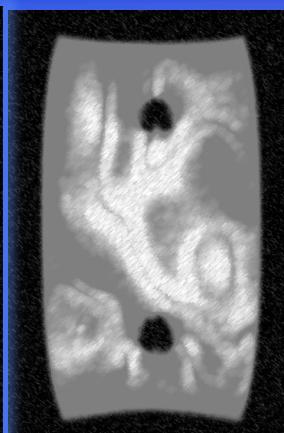
30 sec.

3 sec.

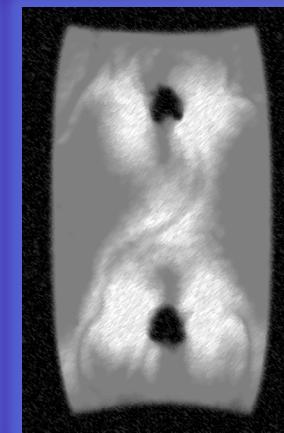
30 sec.



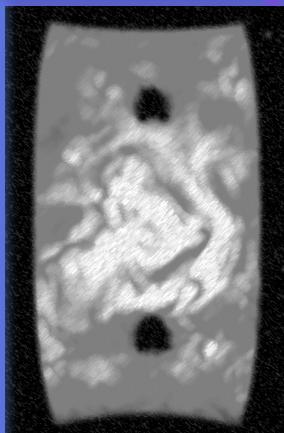
3.5 V



5.0 V



8.0 V



Homogenita magnetického pol'a pre zobrazovací systém na báze magnetickej rezonancie, teória, výpočet a experiment

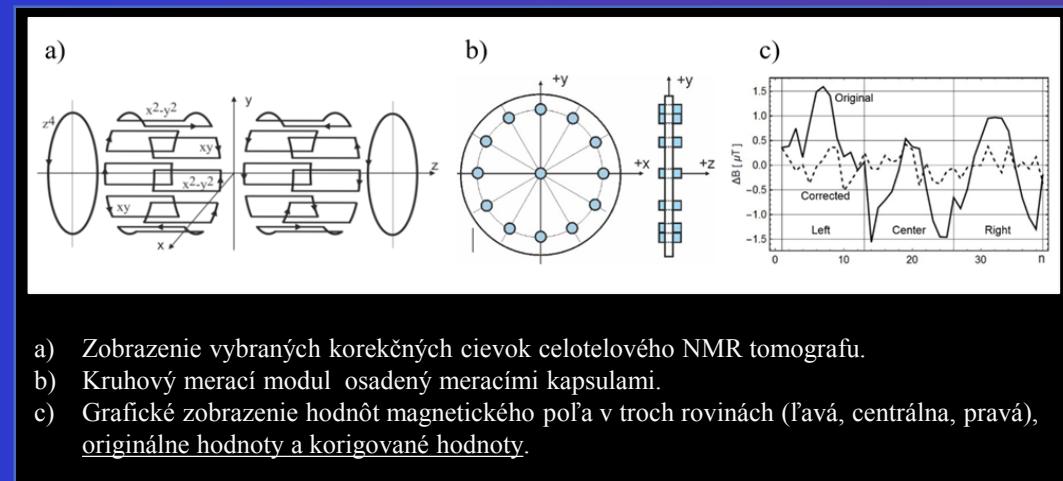
Projekty: **VEGA 2/0001/17, APVV-15-0029**

Aplikátor: **Wega-MS spol. s r.o. Moravany nad Váhom**

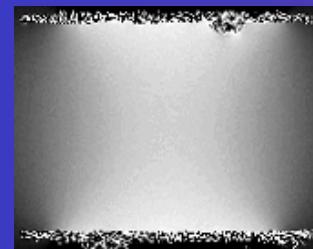
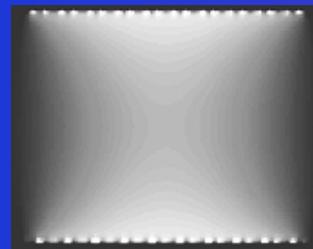
Riešitelia: **I. Frollo, P. Andris, A. Krafčík, D. Gogola, T. Dermek**

Bol navrhnutý nový postup návrhu korekčných (shim) cievok, matematický model, teoretické výpočty a úprava homogenity celotelového tomografa, na základe troch metód merania statického magnetického pol'a.

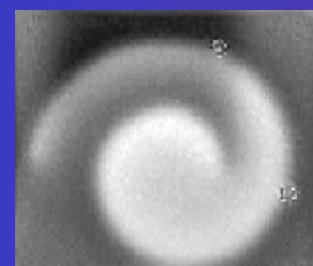
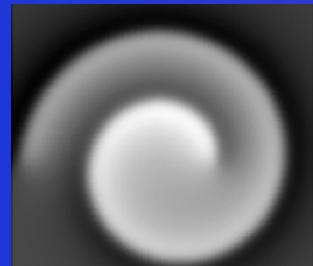
Zobrazovanie na báze magnetickej rezonancie vyžaduje zdroj magnetického pol'a najvyššej homogenity pre celý objem skúmaného objektu



Magnetic field imaging using NMR methods



MF of a solenoidal coil

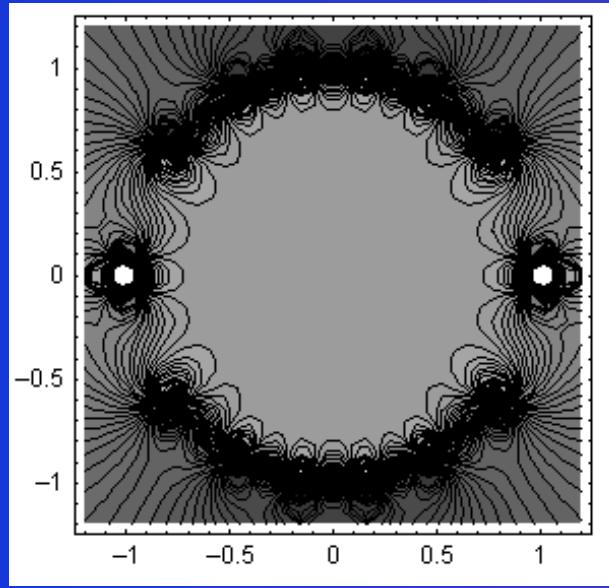


MF of a spiral coil

Calculated magnetic field

Image of the magnetic field using MRI

Magnetic field imaging using NMR methods



Calculated magnetic field

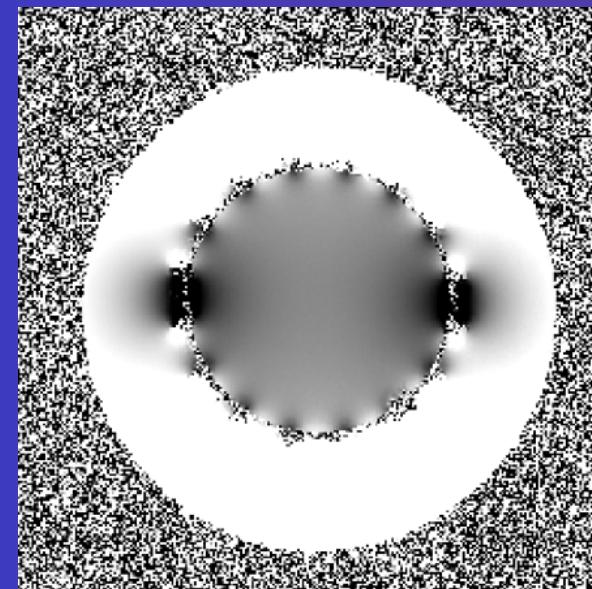
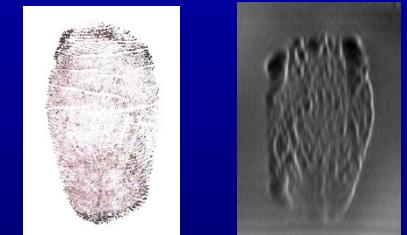
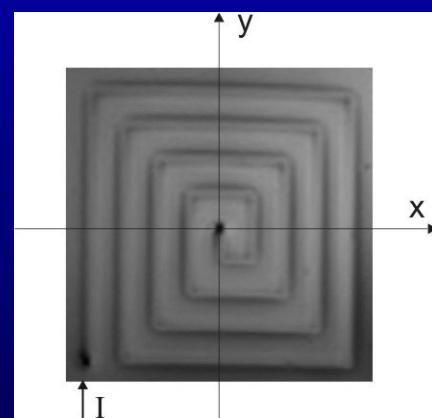
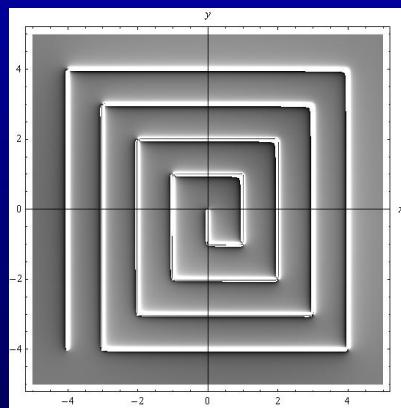


Image of the magnetic field using MRI



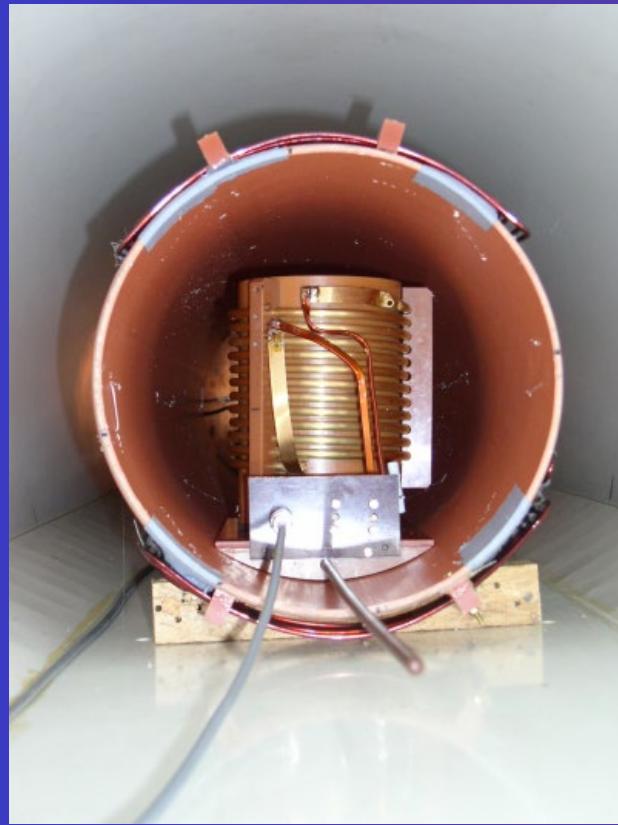
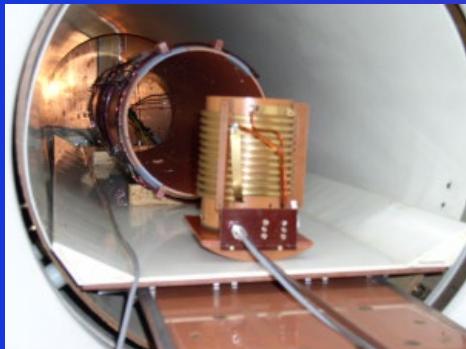
Magnetic field deformation imaging



Biometric imaging
Fingerprints

Density-plot of relative values

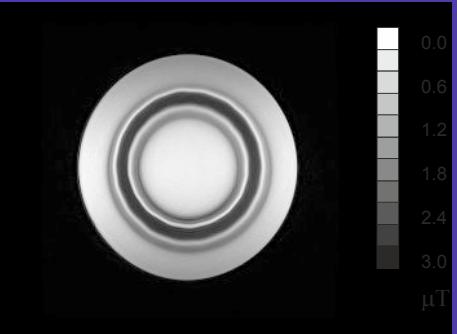
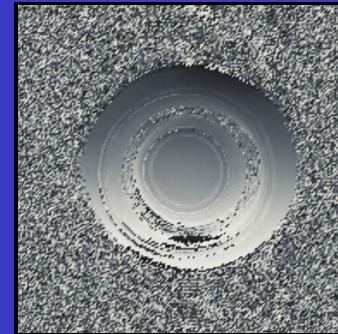
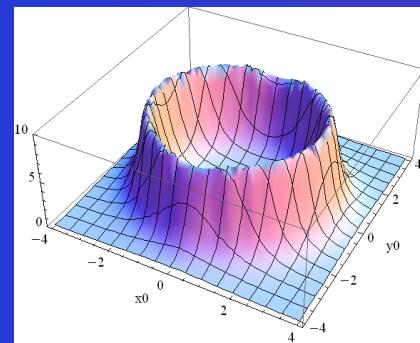
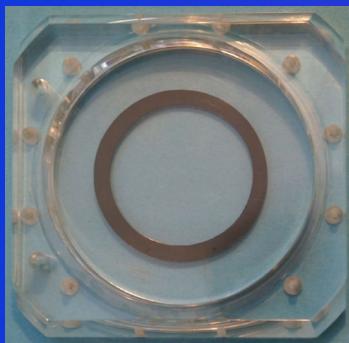
NMR image of the magnetic field distribution of a meander planar coil (60 x 60 mm), number of measured voxels 150 x 150.



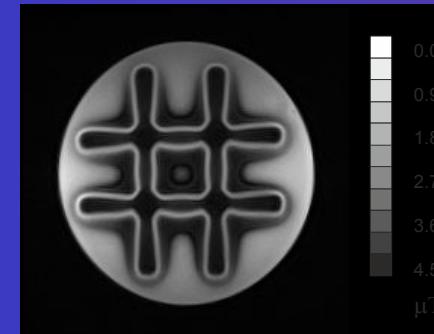
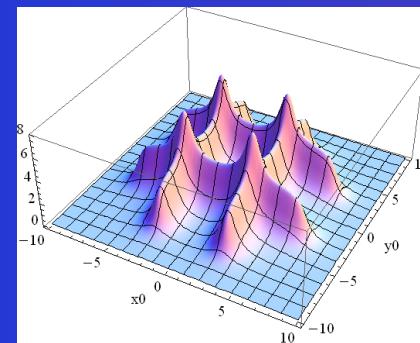
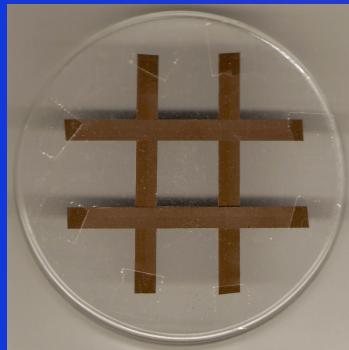
Orientation of a cylindrical RF coil placed into the gantry
with a sample of a magnetic resonance imager 0.1 Tesla

Measurement and imaging of magnetic field changes of soft magnetic materials

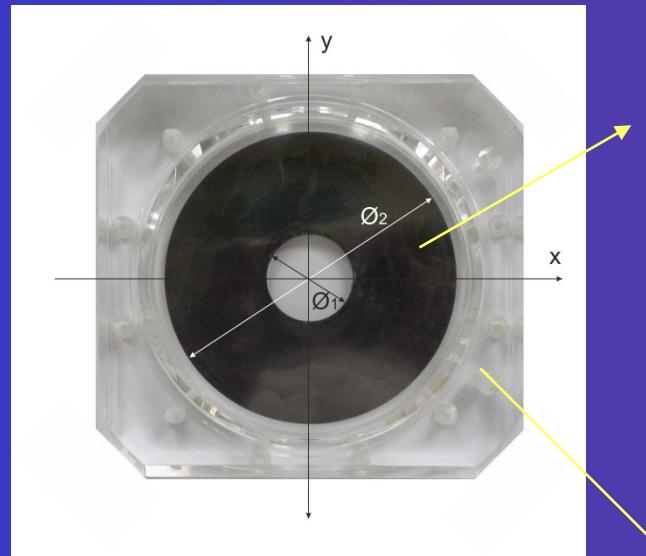
Circular sample



Rectangular sample



Experimental Results



Diskette

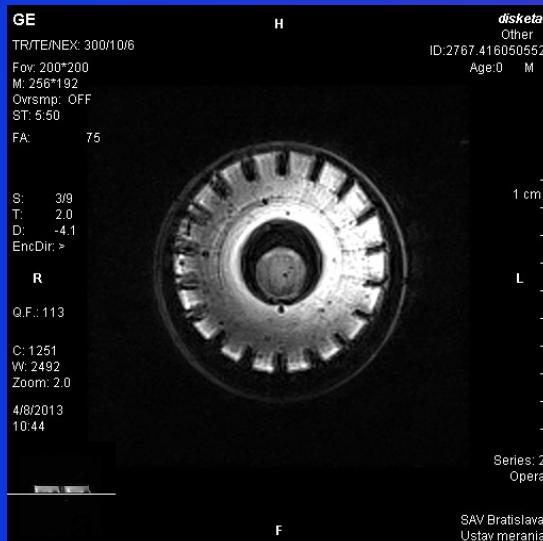
Plastic holder

Left: Verbatim DataLife MF 2HD 3.5" Diskette to store data or programs, in original packing, dimensions 90 x 93 x 3.2 mm.

Right: Plastic circular magnetic disk separated from the diskette case, diameters: $\varnothing_1 = 25$ mm, $\varnothing_2 = 85$ mm, thickness 0.08 mm.

Experimental Results

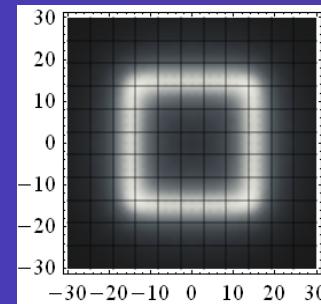
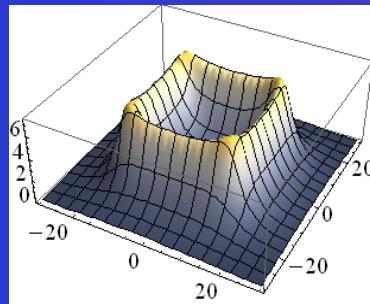
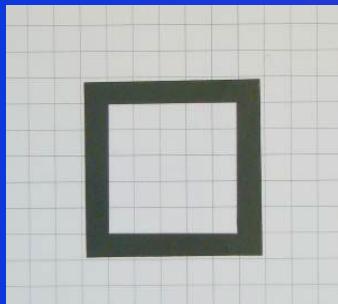
Images of a data diskette



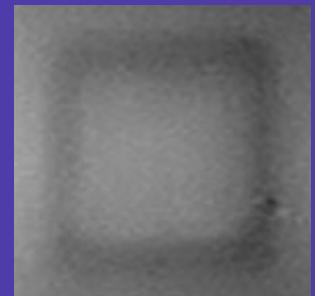
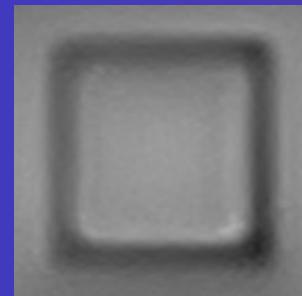
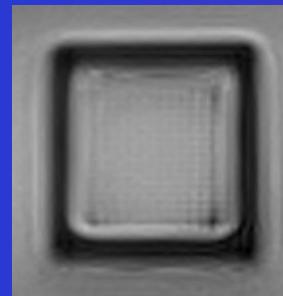
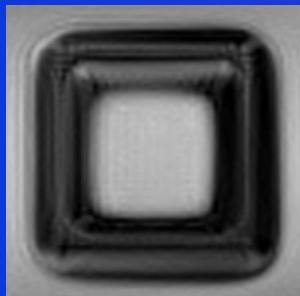
- Original diskette with visible sectors
- Diskette with 2 bigger and 4 smaller stains caused by short magnetization using circular neodymium magnets 1 Tesla.
- Diskette demagnetized by 50 Hz demagnetizer with 10 mm linear slot.

Imaging data: $T_R = 400$ ms, $T_E = 10$ ms, slice thickness 2 mm.

Experimental Results

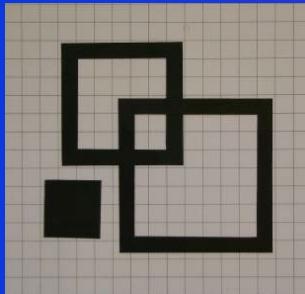


Original sample made as a frame (32 x 32 mm, width 4 mm) cut from a data disc.
Calculated 3D image of the magnetic field distribution, 2 mm above the frame.
Calculated image of the magnetic field of the frame, density plot.

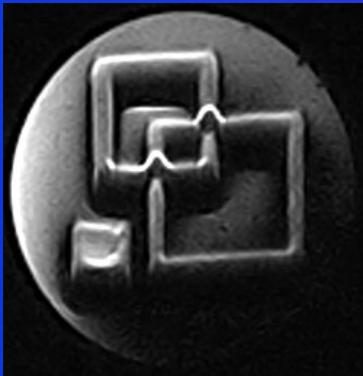


Series of NMR images of the frame sample, Gradient echo imaging sequence, $T_R = 440$ ms, $T_E = 10$ ms. Imaging distance from the plane of sample, from left to right: 4, 6, 8, and 10 mm. Thickness of the imaged layer: 2 mm.

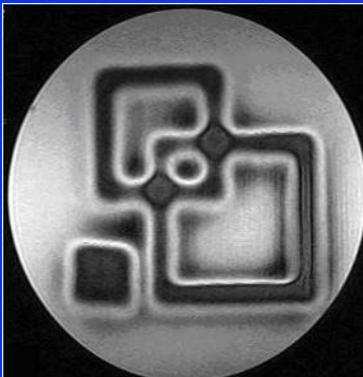
Experimental Results



Original sample: 3 frame objects (cut from a data disc).

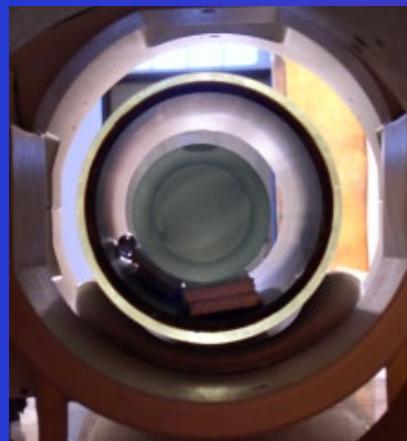


MR image using Spin Echo imaging sequence,
imaging layer distance from the plane of the sample: 4 mm.
Thickness of the imaged layer: 2 mm.

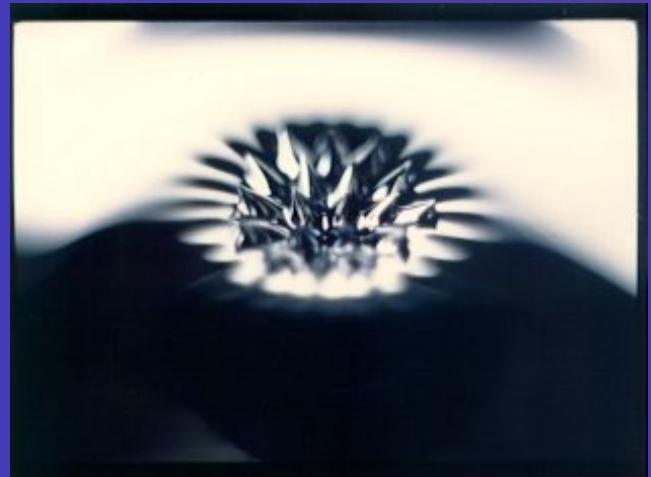


MR image using Gradient Echo sequence,
imaging layer distance from the plane of sample: 6 mm.
Thickness of the imaged layer: 2 mm.

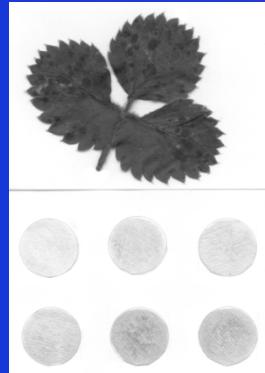
Contrast media – magnetic fluids



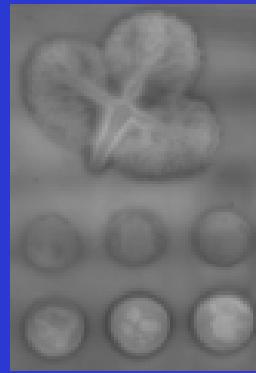
Superparamagnetic Fe_3O_4
nanoparticles as fluid
in 0.1 T imager TMR-96



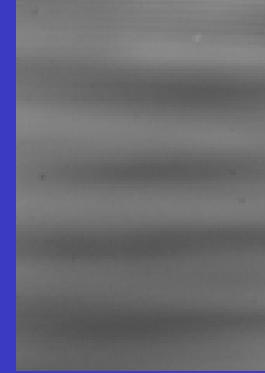
Experiments with imaging of biological samples using magnetic liquids



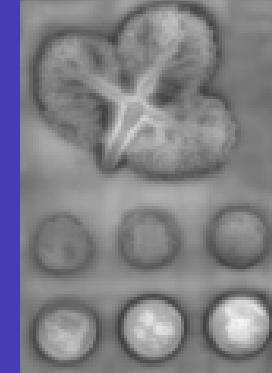
a)



b)



c)

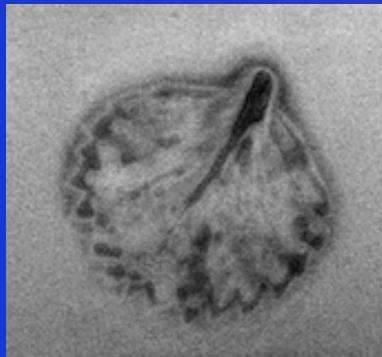


d)

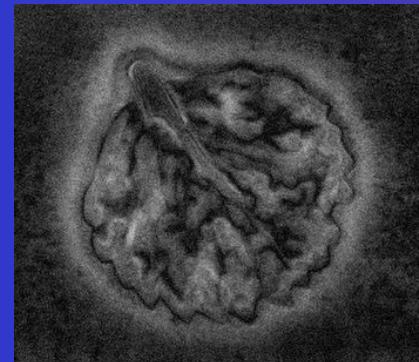
- a) Optical image of the sample.
- b) Image of the sample as a projection into the phantom.
- c) Image of the phantom without sample – background.
- d) Resultant image as a difference: b) – c).

Experiments with imaging of biological samples using magnetic liquids

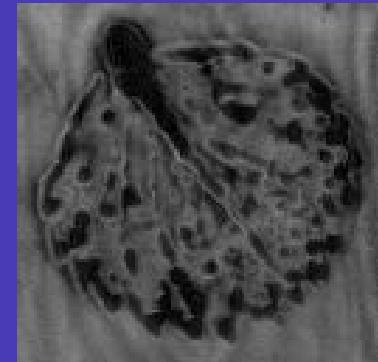
Sample dimension: biological leaf, $\Phi = 30$ mm.



Sampling 256 x 256,
resolution 230 μm .
0.1 Tesla



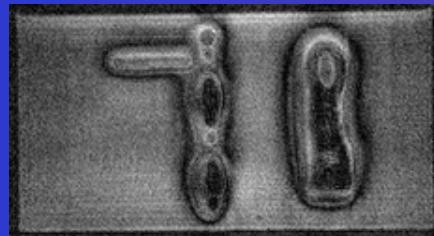
Sampling 512 x 512,
resolution 100 μm .
0.1 Tesla



Sampling 512 x 512,
resolution 100 μm .
4.7 Tesla

Experiments with imaging of physical samples containing magnetic particles

Physical samples, banknotes equipped with hidden integrated magnetic signs

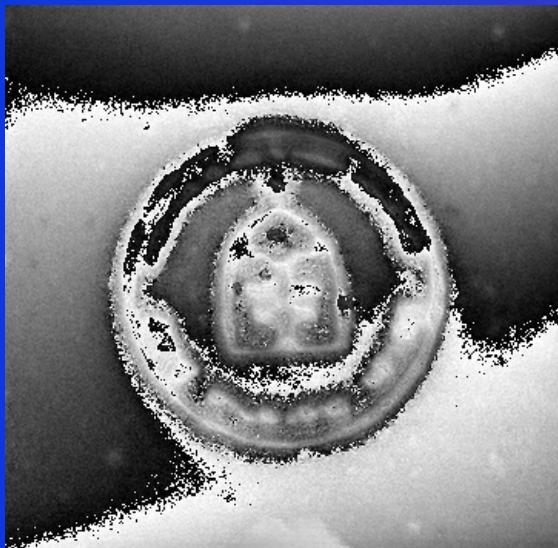


Magnetic image of a banknotes with visible magnetic islands, 512x512 samples.

The banknote was positioned in a plastic holder and placed into the vertical rectangular container (phantom) filled with 0.1 % solution of CuSO₄ in distilled water, for shortening the repetition time TR to 200 ms.

- number of averages was 16
- resolution 150 µm.
- static magnetic field $B_0 = 0.1$ Tesla.

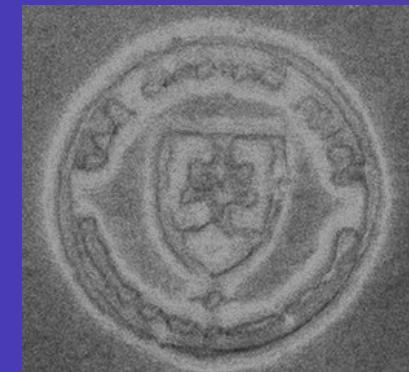
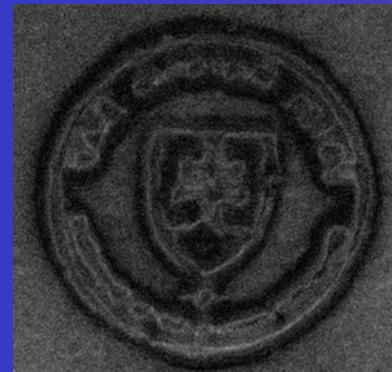
Experiments with imaging of physical samples coated with magnetic particles



Phase image of a business
rubber stamp - print

256 x 256 pixels, resolution 230 micrometers

0.1 Tesla



Amplitude images, positive
and inverse

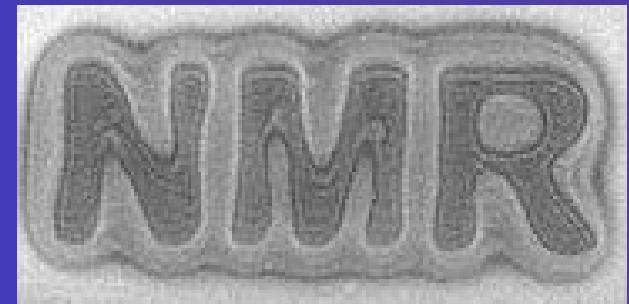
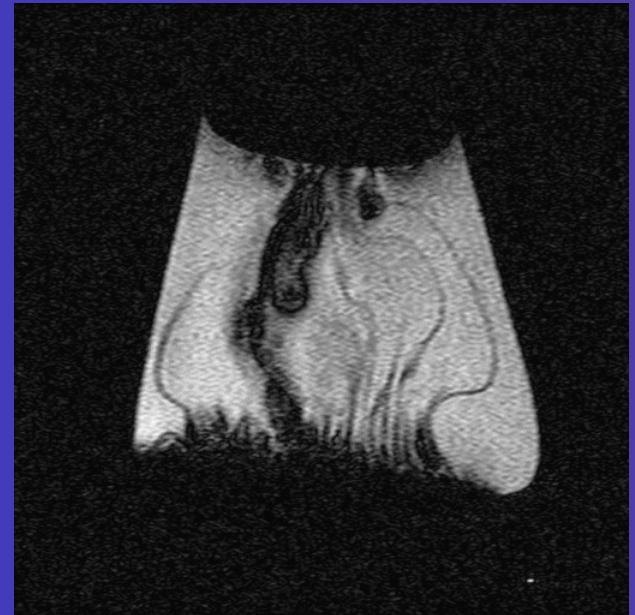
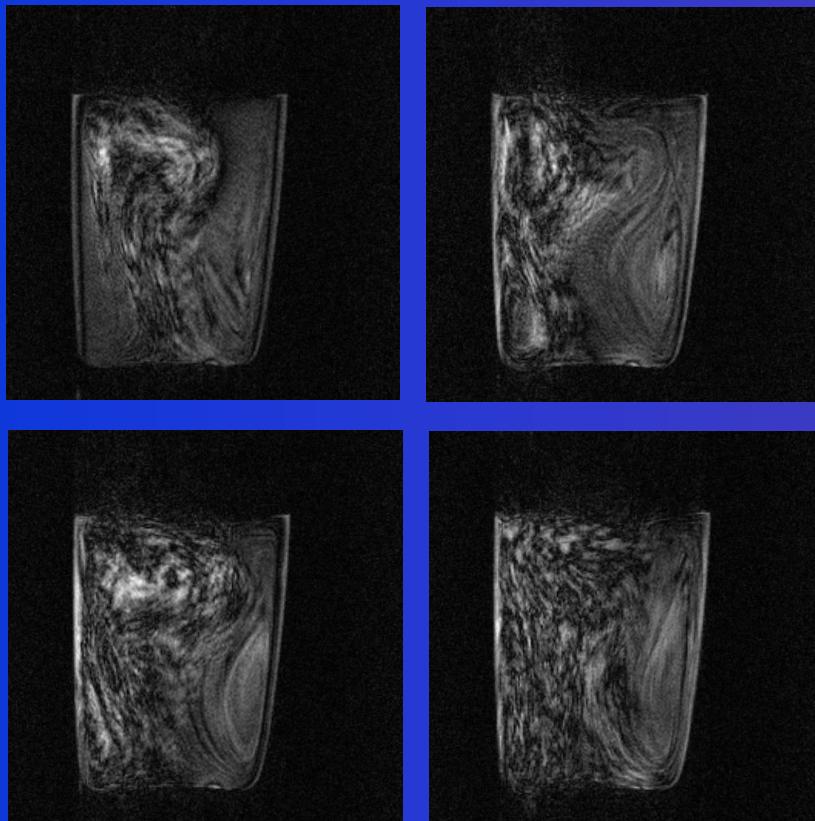


Image of printed letters “NMR”, dimension 55x17 mm,
512x512 samples. Because of the relative high susceptibility
of the magnetic signs a corona appeared around the patterns.

Imaging of magnetic nanoparticles - diffusion in water



Magnetic particles movement due to the Brownian motion in the liquid

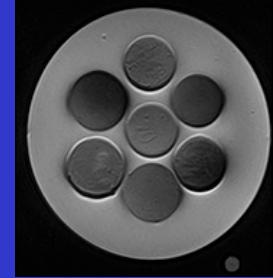
Time differences between images: 120 seconds

Experiments with imaging of physical samples equipped by magnetic nanoparticles using MRI methods

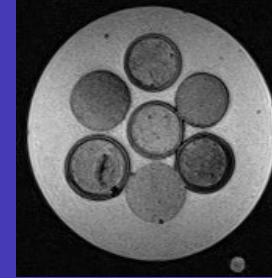
Physical samples, coins, imaging of magnetic inhomogeneities



Foto



Spin-Echo

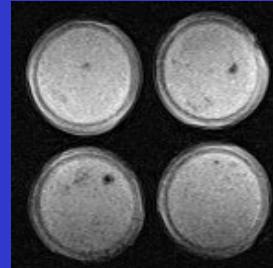


Gradient - Echo

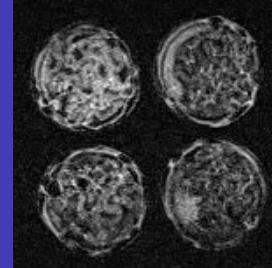
Thin layers of nanoparticles, Fe_3O_4 , in toluen solution



Foto

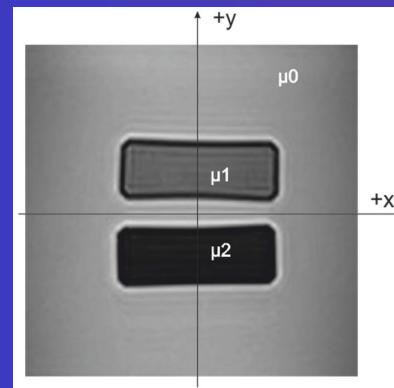
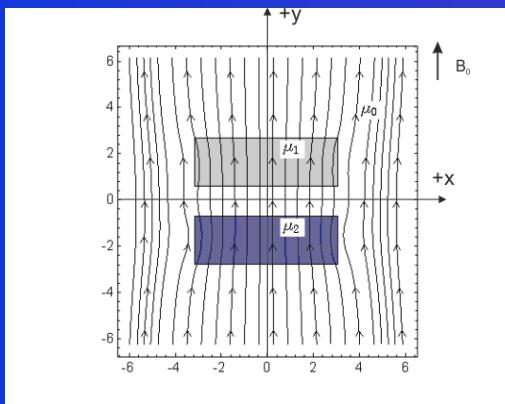


Spin-Echo



Gradient - Echo

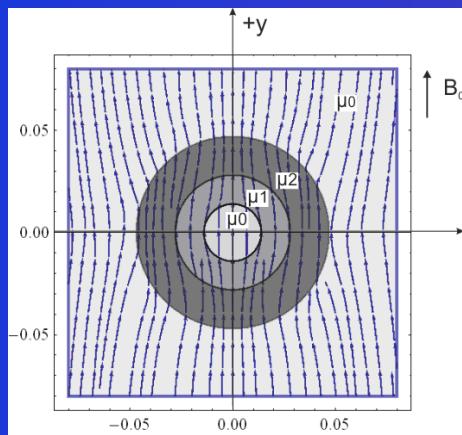
Rectangular Samples



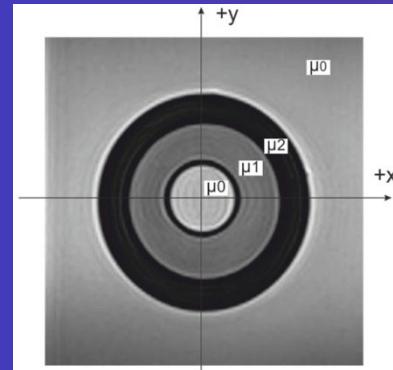
Calculated magnetic field distribution of the homogeneous magnetic field B_0 , lines of force, affected by 2 parallel magnetic bars with relative permeabilities: $\mu_1=2$, $\mu_2=3$ and environment μ_0 .

NMR image of two samples (rectangular vessels filled with doped water in the holder with tap water) using Gradient echo imaging sequence, $T_R = 440$ ms, $T_E = 10$ ms. Thickness of the imaged layer: 2 mm.

Mathematical model



NMR image of two samples



Mathematical model of the distribution of homogeneous magnetic field H_0 , lines of force affected by 2 concentric cylinders with relative permeabilities: $\mu_1=2$ and $\mu_2=3$, μ_0 is an environment permeability.

NMR image of two samples (circular vessels filled with doped water in the rectangular vessels - holder filled with tap water) using Gradient echo imaging sequence: $T_R = 440$ ms, $T_E = 10$ ms. Thickness of the imaged layer: 2 mm.

Imaging of botanical samples



Green coffee beans, 4 x 4 x 8 mm, 20% water, 10% fat

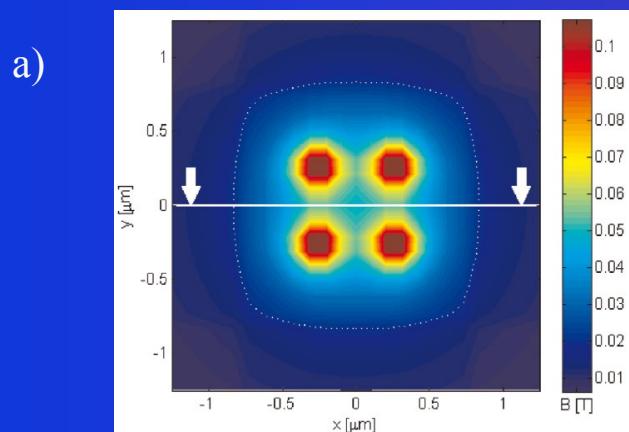
Najvýznamnejšie výsledky - základný výskum

Výskum deformácie statického magnetického pola z dôvodu prítomnosti magnetických nanočastíc metódami zobrazovania na princípoch MR

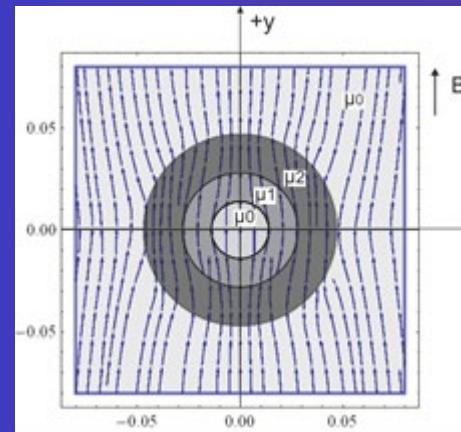
Projekty: VEGA 2/0013/14 a APVV-0431-12

Riešitelia: I. Frollo, O. Štrbák, A. Krafčík, D. Gogola

Nanočastice ako kontrastné médium majú magnetický moment, ktorý generuje lokálne nehomogenity statického magnetického pola MR tomografu. Cieľom výskumu bolo vyšetriť vplyv magnetických nanočastíc na finálny kontrast obrazu kruhových vzoriek počas MRI.



b)



- a) Kontúrové zobrazenie magnetického pola štyroch nanočastíc. Vzdialenosť nanočastíc: 50 nm.
Veľkosť kontúry pri hodnote magnetického poľa 0.02 Tesla je 160 nm.
- b) Matematický model rozloženia homogénneho magnetického poľa B_0 , zobrazenie tvaru siločiar vplyvom 2 koncentrických valcov s relatívnou permeabilitou: $\mu_1=2$ and $\mu_2=3$, μ_0 = prostredie.

Najvýznamnejšie výsledky - medzinárodné vedecké projekty

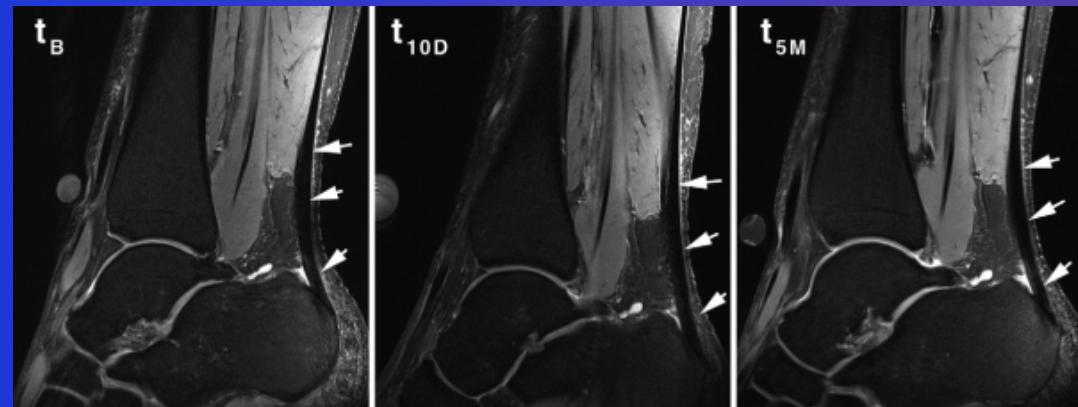
Multiparametrické metódy kvantifikácie stavu kolagénových vlákien v chrupavkách prostredníctvom merania relaxačných parametrov

Projekty: VEGA 2/0013/14

Riešitelia: V. Juráš, P. Szomolányi, I. Frollo

Zahraničný partner: Univ.-Prof. Dr. Siegfried Trattnig, Medical University of Vienna, Austria.

In-vivo metóda kvantifikácie stavu kolagénových vlákien v chrupavkách ľudských končatín prostredníctvom merania T2 relaxačných parametrov pri súčasnej aplikácii fyziologického tlaku na chrupavku. Kolagénové vlákna a glykózaminoglykány sa dajú kvantifikovať metódou magnetickej rezonancie na základe merania dĺžky relaxačných časov.



Morfologický obraz pacienta v základnom stave pred príjomom lieku ciprofloxacin (t_B), 10 dní po prísune ciprofloxacínu (t_{10D}), a teste po 5-mesiacoach (t_{5M}). Sodíkové (^{23}Na) MRI zobrazovanie ukázalo štatisticky signifikantné zmeny 10 dní po podaní ciprofloxacínu. Publikované v 3 CC časopisoch.

ODDELENIE ZOBRAZOVACÍCH METÓD

Ing. Ivan Frollo



*Vedecká ašpirantúra na Ústave merania SAV: 1963 – 1966
1967 - CSc.*

1972 – samostatný vedecký pracovník

1985 – vedúci vedecký pracovník

1993 - docent,

1995 - profesor

ODDELENIE ZOBRAZOVACÍCH METÓD

Prof. Ing. Ivan Frollo, DrSc.



Orientácia vedeckého výskumu:

Meracie metódy a systémy založené na princípe nukleárnej magnetickej rezonancie (NMR) pri nízkom magnetickom poli. Nové zobrazovacie metódy z hľadiska špeciálnych snímačov na celotelové zobrazovanie a mikro-zobrazovanie. Nelineárne metódy adaptívnej filtrácie a segmentácie MR obrazov.

Motivácia: Polročný študijný pobyt: University of California Berkeley 1977, NMR laboratórium, prof. Singer

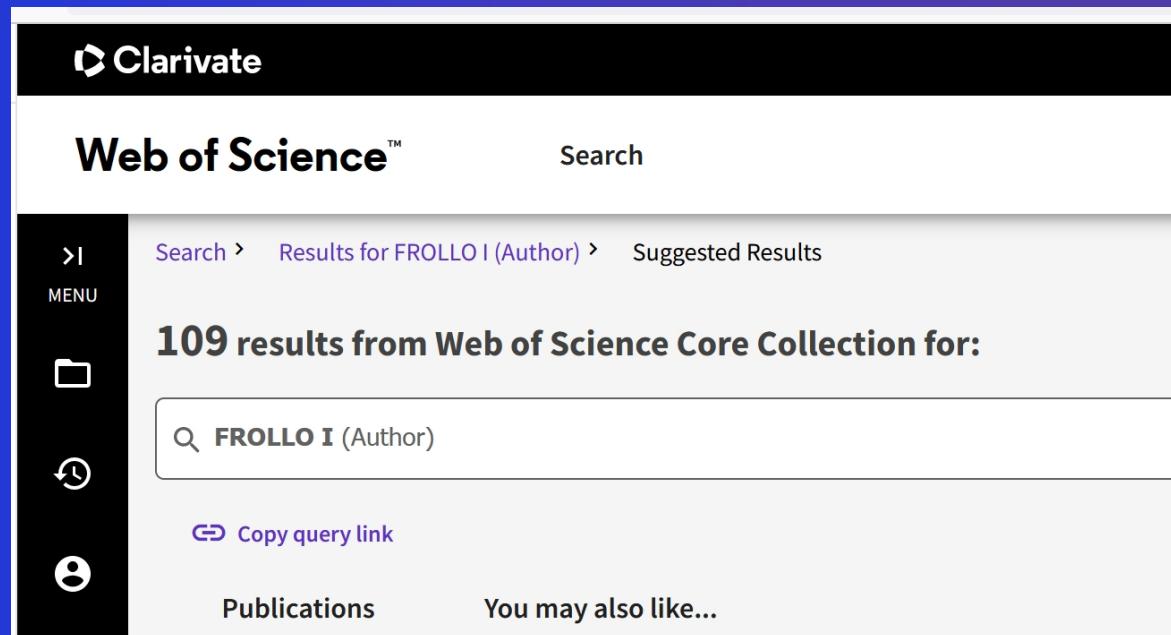
ODDELENIE ZOBRAZOVACÍCH METÓD

Prof. Ing. Ivan Frollo, DrSc.

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Academic of Central European Academy of Science and Art
Active member of New York Academy of Sciences

Publications:



The screenshot shows a search results page from the Web of Science Core Collection. At the top, the Clarivate logo and the "Web of Science™" logo are visible, along with a "Search" bar. The search query "FROLLO I (Author)" is entered. The results are displayed under the heading "109 results from Web of Science Core Collection for:". Below this, there is a search bar with the same query and a "Copy query link" button. At the bottom of the visible area, there are links for "Publications" and "You may also like...".

Patents: 22 patents confirmed by a certificate and applied in praxis.

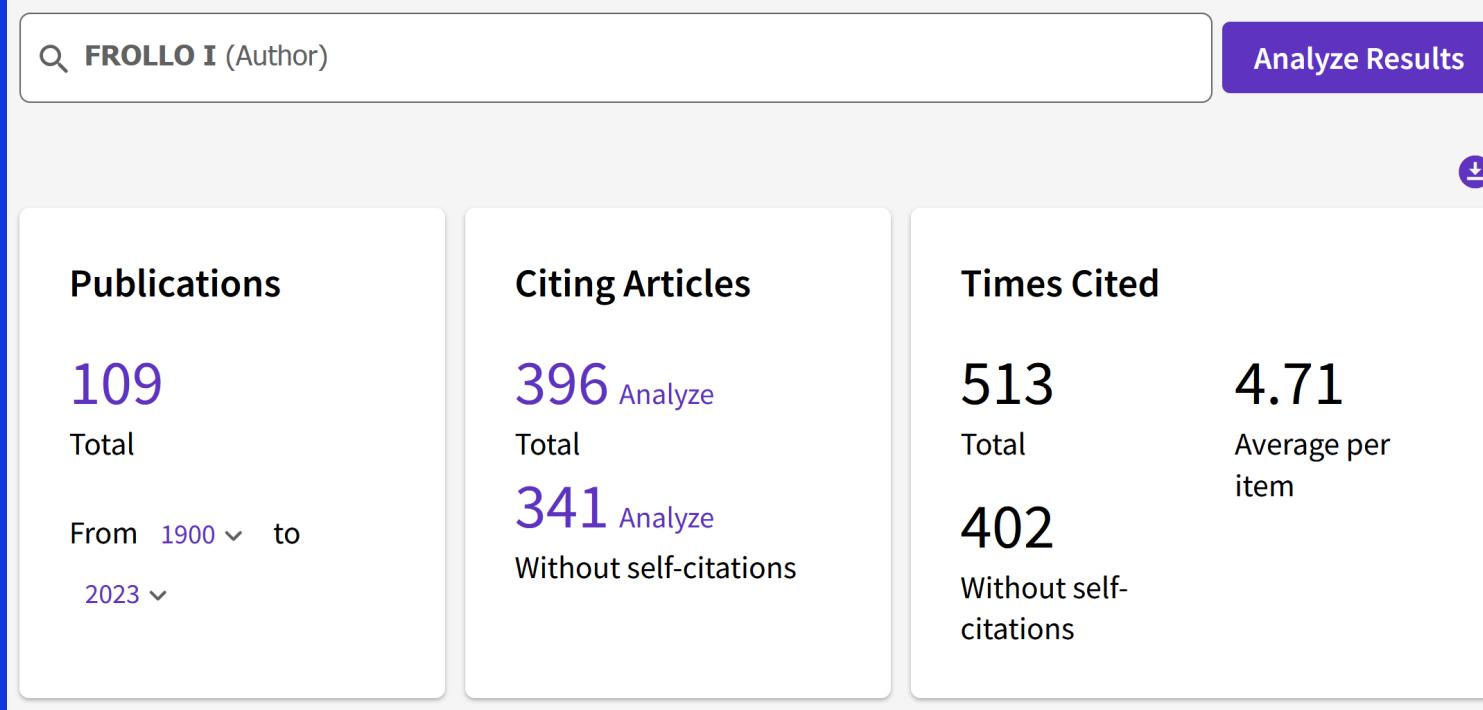
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Prof. Ing. Ivan Frollo, DrSc.

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Citations: vd'aka výborným spolupracovníkom Odd. 04

Citation Report



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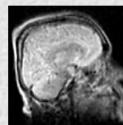
Phone: + 4212 5910 4540



My official profile



My violin (1899)



My sagittal profile



My picture



My hand



My piano - my music

My awards



Position

Head of the Department of Imaging Methods,
Institute of Measurement Science,
Slovak Academy of Sciences, Bratislava

Popularizácia

Noc výskumníkov 2018, 2019, 2020, 2022



**Tomografia -
pohľad do vnútra
objektov**

Princípy zobrazovania na báze magnetickej rezonancie a CT



Ďakujem za pozornosť

SLOVENSKÁ AKADÉMIA VIED

ÚSTAV MERANIA

INSTITUTE OF MEASUREMENT SCIENCE

70

Oddelenie zobrazovacích metód

1953 – 2023

