



Institute of Measurement Science, Slovak Academy of Sciences

Ústav merania Slovenskej akadémie vied

International Evaluation Panel Meeting with the Institute Research Community within SAS Evaluation in 2016

November 11, 2016



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Ústav merania Slovenskej akadémie vied

The Institute

- ❑ is one of 15 institutes of the SAS Section I:
Mathematical, Physical, Space, Earth, and Engineering Sciences
- ❑ belongs to institutes of engineering sciences
- ❑ **is oriented to interdisciplinary research of measuring methods in areas including natural, technical, engineering and medical sciences**



Institute Mission

- ❑ Basic Research
 - Theory of measurement, mathematical/statistical methods for processing of experimental results
 - Measuring methods for selected fields of physics, material science and biomedicine
- ❑ Applied Research
 - Solving of non-standard problems of measurement in research, industry and medicine
 - Development and realization on unique measuring systems
- ❑ Dissemination of Research Results
 - Publishing of scientific journal Measurement Science Review
 - Organizing international conferences
 - Supervising graduate and postgraduate students
 - Popularization of science



Institute Structure

- ☐ Department of Theoretical Methods
 - ☐ Department of Optoelectronic Measuring Methods
 - ☐ Department of Magnetometry
 - ☐ Department of Imaging Methods
 - ☐ Department of Biomeasurements
-
- Technological Department
 - Library

IMS SAS building
SAS campus Bratislava - Patrónka





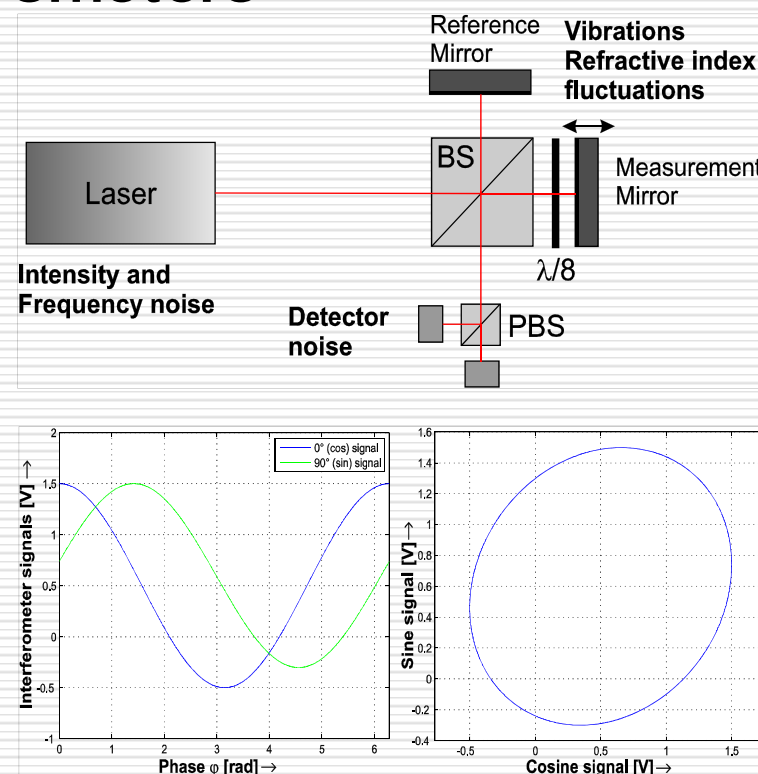
Department of Theoretical Methods

- ❑ Mathematical and statistical methods for measurement science and metrology
- ❑ Mathematical modeling and nonlinear dynamic systems
- ❑ Scientific computing and applied informatics

Statistical methods for metrology

Uncertainty of displacement measurements by quadrature homodyne interferometers

- ❑ Quadrature homodyne interferometers allow to perform very precise measurements (with nanometer up to pico-meter precision).
- ❑ Original method for proper **determination of measurement uncertainties** based on evaluation of the parameters of ellipse created by the two phase-shifted signals
- ❑ Cooperation with PTB Braunschweig (Physikalisch-Technische Bundesanstalt, Germany)

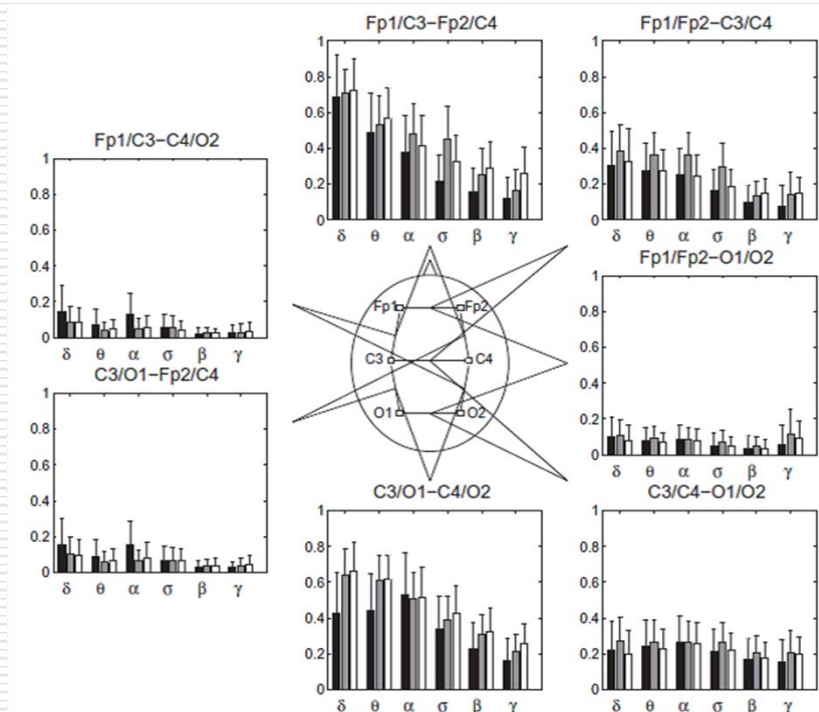


The principle and of typical measured signals by using the quadrature homodyne interferometer

Modeling and nonlinear dynamic systems

Coherence and phase synchronization on sleep electroencephalograms

- ❑ **Synchronization measures** were suggested and applied to the electroencephalogram (EEG). They reflect the level of coordination between different parts of the cerebral cortex.
- ❑ Different levels of synchronization between specific brain parts were found
- ❑ In cooperation with the Institute of Computer Science, Academy of Sciences of the Czech Republic.



EEG coherence between the head areas during waking hours (black), in nonREM sleep (grey) and in REM sleep (white).



Scientific computing and applied informatics

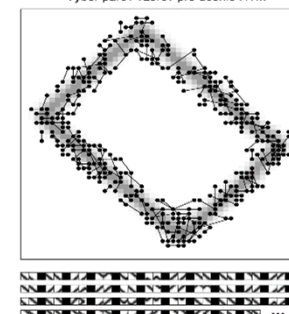
Hierarchical Temporal Memory networks used in computer vision applications

- ❑ Several modifications to conventional learning algorithms of the Hierarchical Temporal Memory (HTM) were proposed using a bio-inspired large-scale model of the neocortex, used in computer vision applications as an efficient classifier.
- ❑ The suggested method yields significantly faster convergence
- ❑ PhD project supported by „e-talent“ grant of Tatra Bank Foundation.

Generovanie codebooku pomocou M-H algoritmu



Výber párov vzorov pre učenie HTM



Left: An illustration of the principle of the image pattern codebook generation using Metropolis-Hastings algorithm.

Right: Graphical presentation of an example of the HTM network training by the method of temporal pooling of image patterns sampled from Brownian random walk across the training images.



Department of Optoelectronic Measuring Methods

- ☐ Microtomographic methods
- ☐ Optical measuring methods for mechanical and power engineering
- ☐ Non-destructive testing (NDT) methods for preservation of cultural heritage

Microtomographic methods

❑ X-ray microtomography

Microtomograph Nanotom 180 is a kind of microscope in X-ray computed tomography. Maximal height of the scanned object is 15 cm, resolution after the 3D reconstruction is down to 0.5 μm .

Methods of microCT are used for non-destructive visualisation of internal structure of objects and materials in:

- material research, mechanical engineering
- microelectronics,
- biology
- geology, paleontology
- preservation of cultural heritage



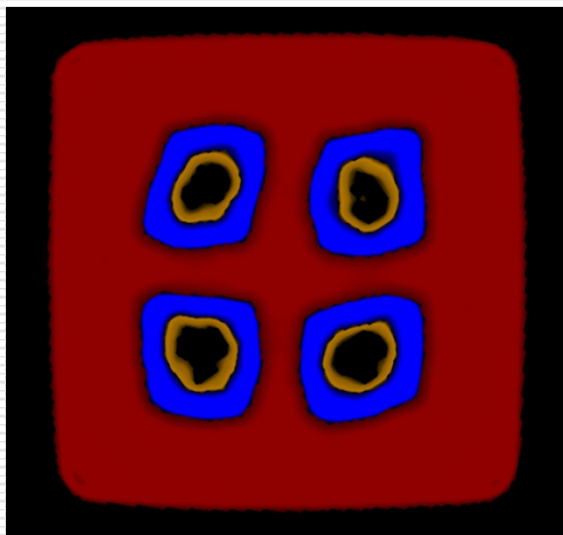
View of microCT laboratory



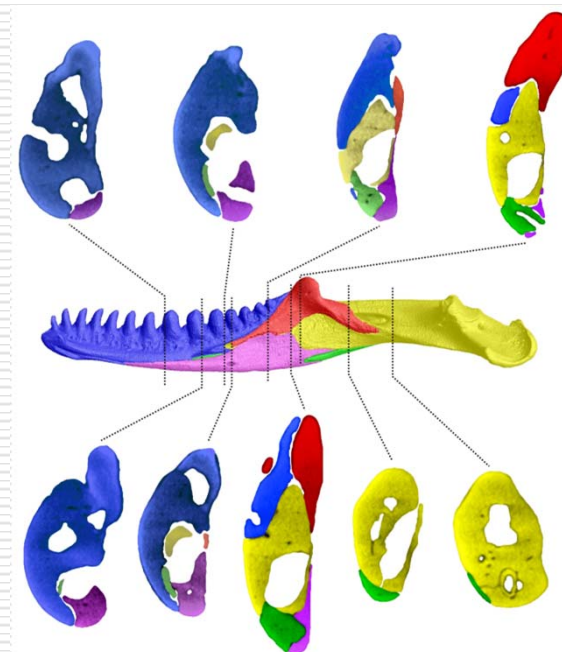
View and section of a fly

Microtomographic methods

Cooperation with other research institutes.
Scientific impact (5 CC papers)



Segmented microCT section of a four-wire superconductor 5x5 mm (cooperation with Dr.Kováč, Inst. of Electrical Engineering SAS)

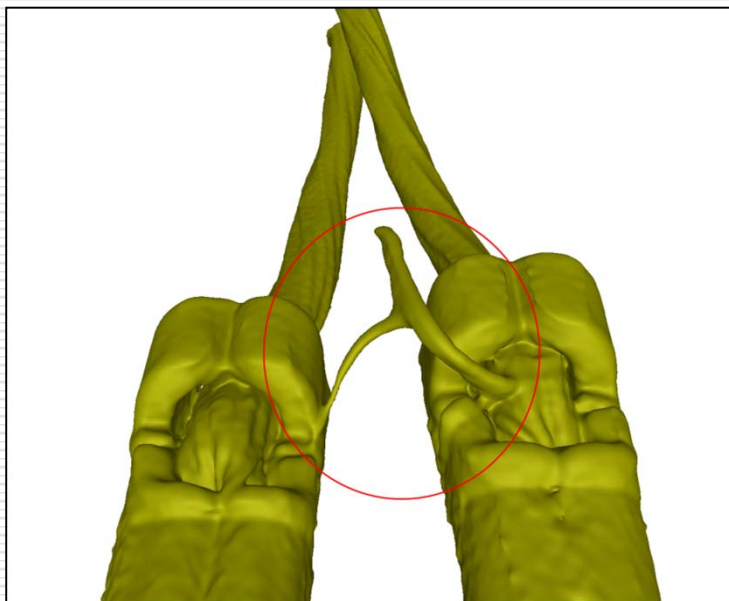


Segmented microCT sections of lower jaw of Pseudopus Apodus - 3 mm (cooperation with Prof. Klembara, Faculty of Natural Sciences, Comenius University Bratislava)

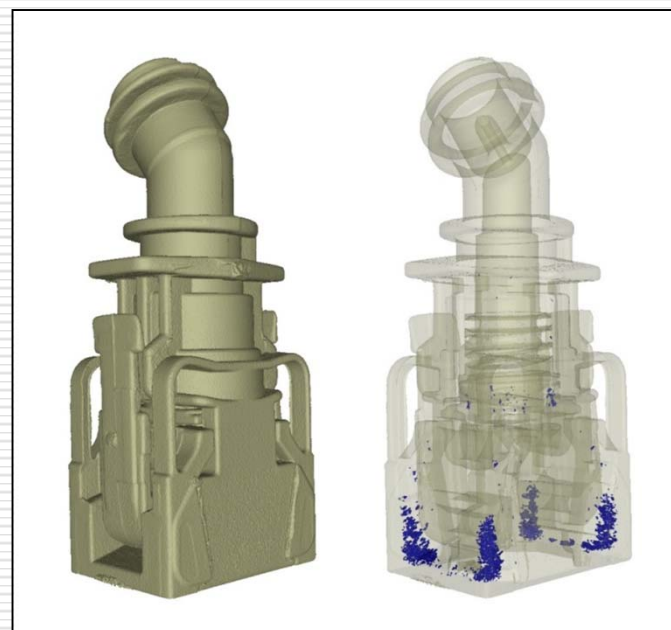


Microtomographic methods

Cooperation with industry partners by the application of microCT methods has extensive technical and economical impact (improving of production technologies)



MicroCT visualisation of a short circuit in an electric coil



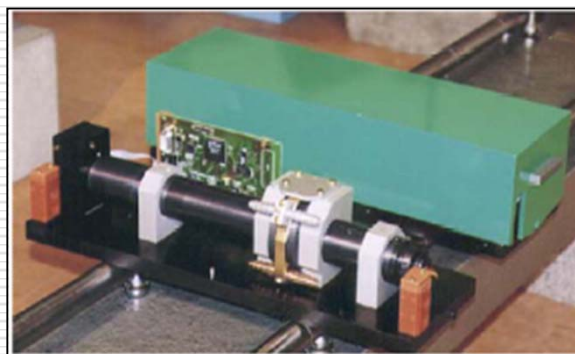
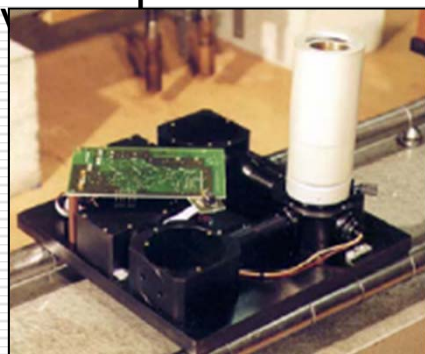
Defects – air bubbles (10 μm) in a plastic housing of a connector

Measurement of stability of large objects

Method and system for measurement of the tilt of all reactor vessels in nuclear power plants in Bohunice and Mochovce

Pendometric sensor for the tilt measurement of nuclear reactor vessels

Sensor for the hydrostatic leveling and tilt measurement of the system for the tilt measurement of reactor vessels installed on the chamber of the reactor

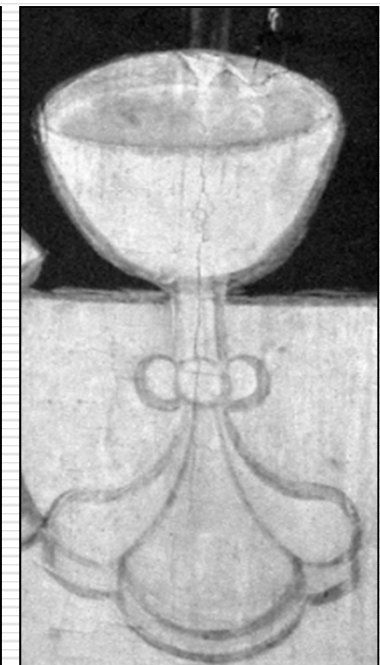




Optical methods for nondestructive Testing

- ☐ Active infrared thermography
- ☐ Ultraviolet fluorescence
- ☐ Infrared reflectography

Photo of a painting in visible light
and near infrared reflectogram
(revealed charcoal under-drawing)



Invisible text of the wall painting
visualized by the ultraviolet fluorescence



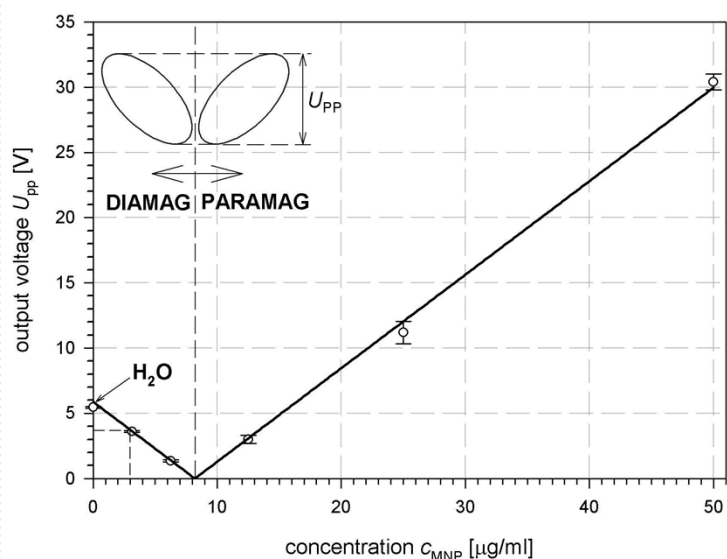


Department of Magnetometry

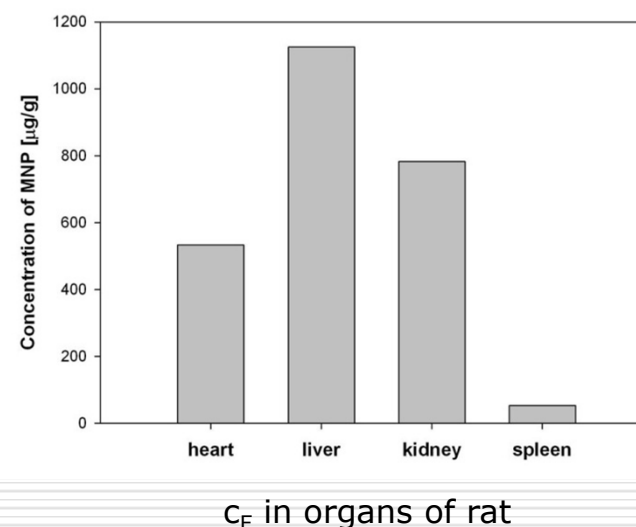
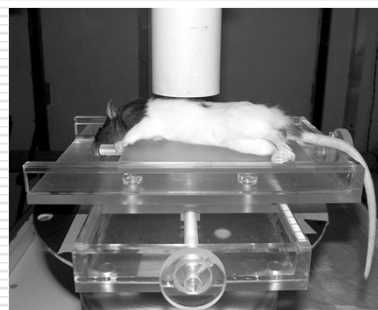
- ❑ Development of SQUID magnetometric methods for magnetic nanoparticles and nanoliquids
- ❑ Synthesis of nanomaterials based on Vanadium
- ❑ Research of superconducting model of the magnetic admixtures in diamagnetic matrix
- ❑ Research of magnetic properties of ferroliquids

Magnetic study of nanoparticles as drug carriers

- Research on colloidal solutions and laboratory animals by one-channel 2nd order SQUID gradiometer using a low-frequency magnetic field and coated Fe_3O_4 nanoparticles (cooperation with Faculty of Medicine)



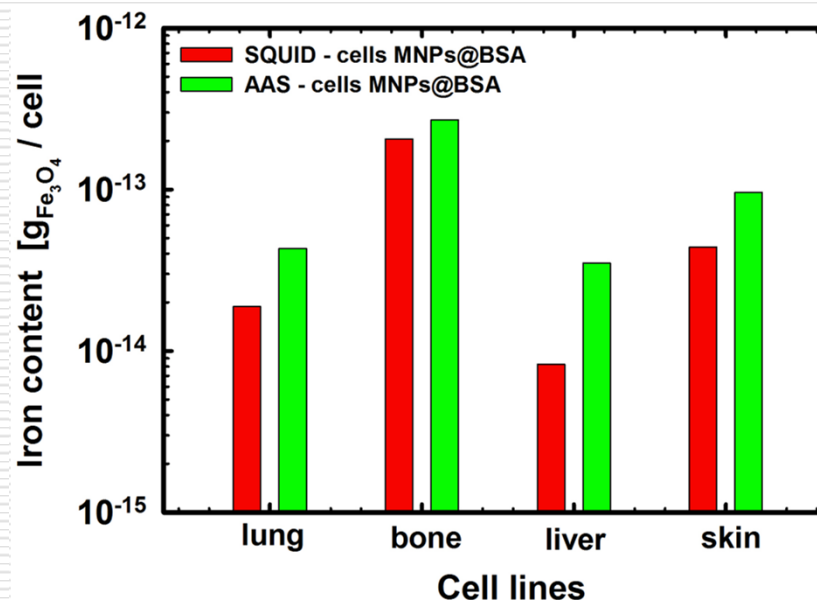
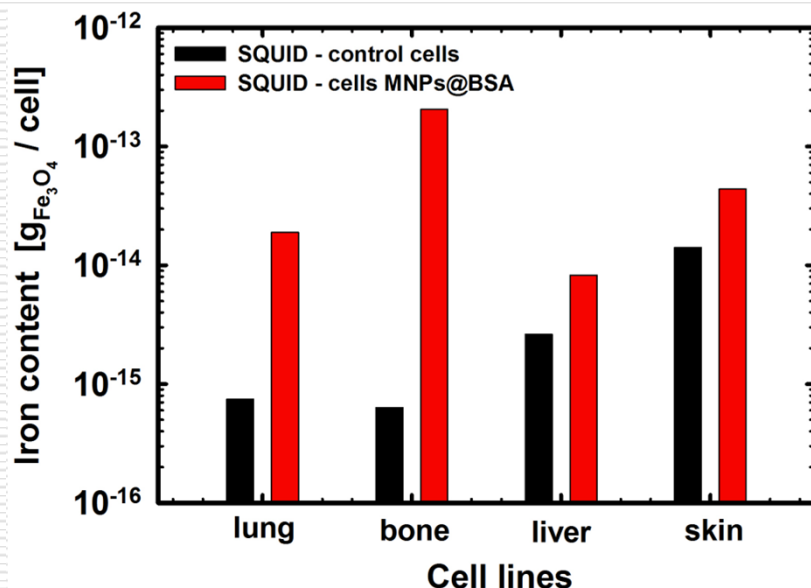
The dependence of U_{PP} on c_{MNP} for $d_M = 0.002 \text{ m}$, $V_{M2} = 54 \times 10^{-6} \text{ m}^3$



Estimated **sensitivity of measurements** of the concentration of nanoparticles in small volume samples (like laboratory animals organs) in the biological tissues and colloidal solutions is **3-5 $\mu\text{g Fe}_3\text{O}_4 / \text{cm}^3 \text{H}_2\text{O}$**

Magnetic study of nanoparticles as drug carriers

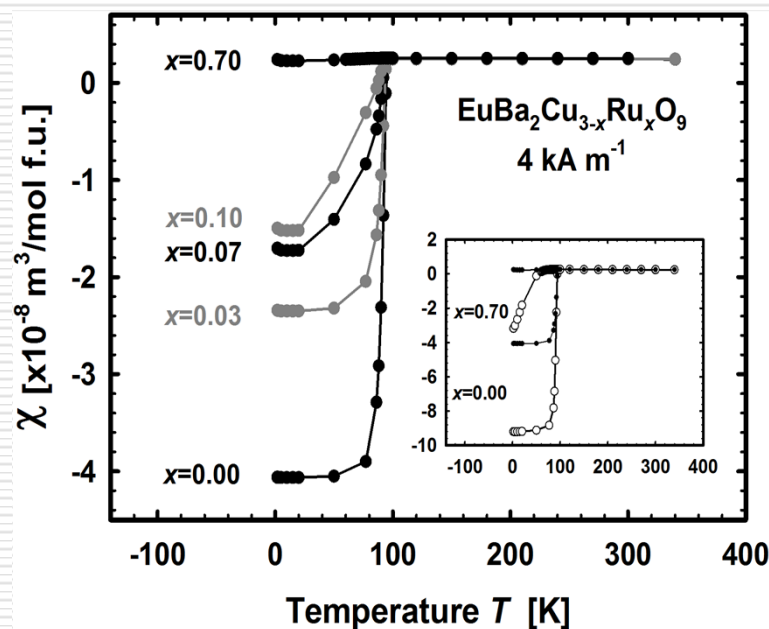
- Research on uptaken coated magnetite nanoparticles by human cell lines by SQUID susceptometer MPMS XL 7AC (cooperation with Cancer Research Institute)



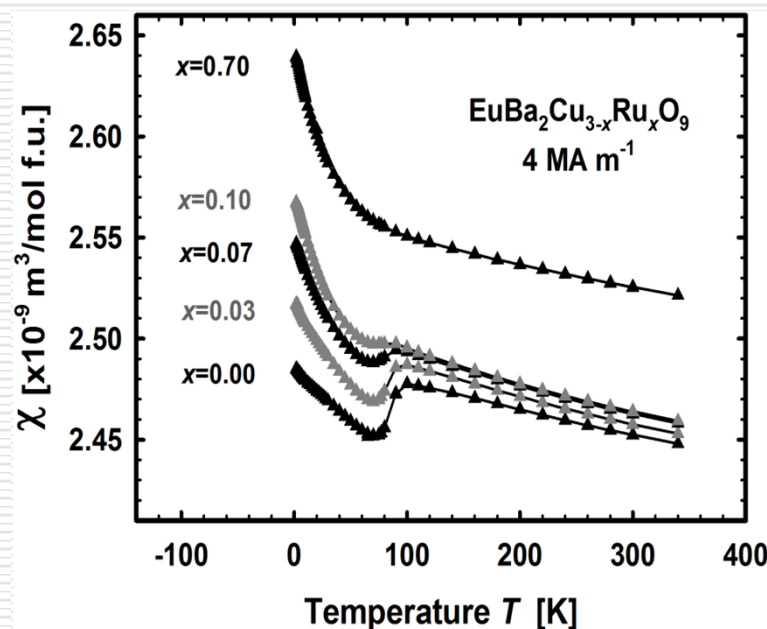
Comparison of SQUID and atomic absorption spectroscopy determination of the iron content in the cell

Study of superconducting model of the magnetic admixtures in diamagnetic matrix on high-T_c Eu-123 superconductor doped by Ru

The obtained results imply possible new way to study the interaction between diamagnetic and magnetic media using the superconductors and temperature or magnetic field as keys for turning of their diamagnetic properties



FC χ vs. T dependences of the $\text{EuBa}_2\text{Cu}_{3-x}\text{Ru}_x\text{O}_{7-\delta}$ samples with shown x at 4 kA m^{-1}



FC χ vs. T dependences of the $\text{EuBa}_2\text{Cu}_{3-x}\text{Ru}_x\text{O}_{7-\delta}$ samples with shown x at 4 MA m^{-1}

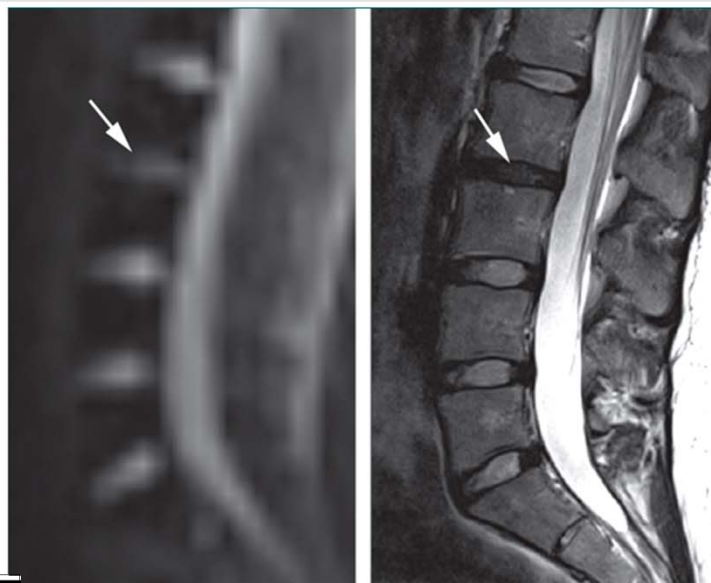
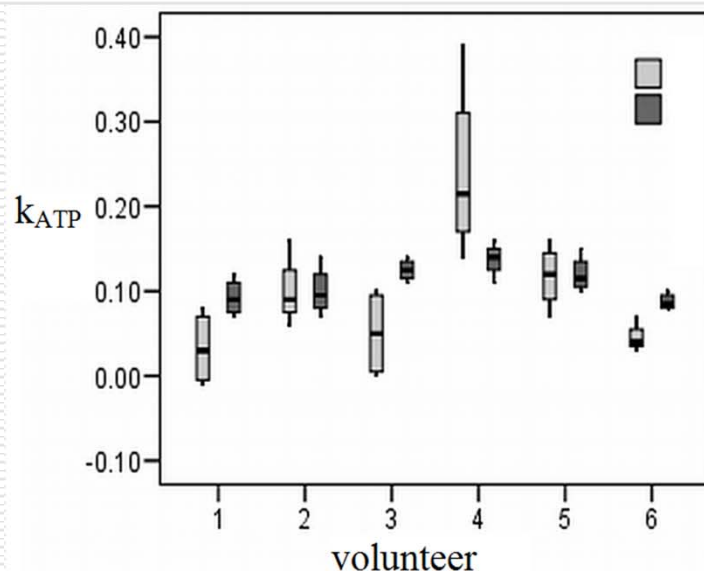


Department of Imaging Methods

- ❑ Advanced tomographic methods using NMR for material research, medicine and biology
- ❑ Development of new tomographic systems



New magnetic resonance imaging and diagnostic methods of musculoskeletal system – sodium MR imaging



Sodium MR Imaging of the Lumbar Intervertebral Disk at 7 T: Correlation with T2 Mapping and Modified Pfirrmann Score at 3 T—Preliminary Results¹

7 T: Correlation with T2 Mapping and Modified Pfirrmann Score at 3 T—Preliminary Results¹

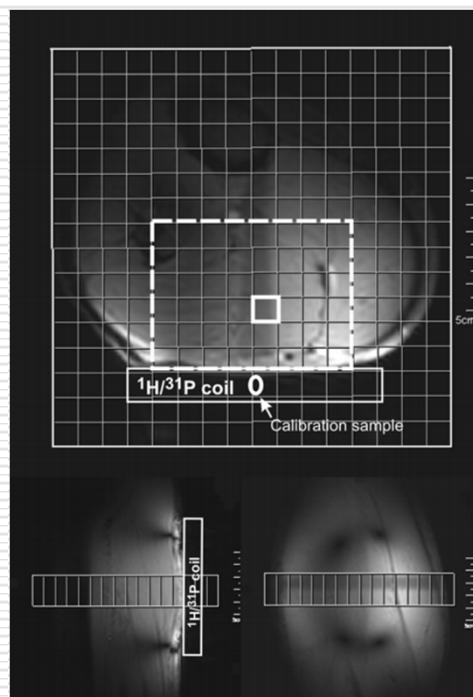
Iris-Melanie Noebauer-Huhmann, MD
Vladimir Juras, PhD
Christian W. A. Pfirrmann, MD
Pavol Szomolanyi, PhD

Purpose: To compare sodium imaging of lumbar intervertebral disks in asymptomatic volunteers at 7-T magnetic resonance (MR) imaging with quantitative T2 mapping and morphologic scoring at 3 T.

Right. MR image of the lumbar spine with possible intervertebral disk pathology.

Left: MR image of **sodium content** in intervertebral disks, the arrow indicates the place of pathology with lower glycosaminoglycan concentration.

Measurement of muscle metabolism using phosphorus spectroscopy on ultra-high fields



In-vivo measurement on 7 Tesla MR. The grid represents spectroscopic

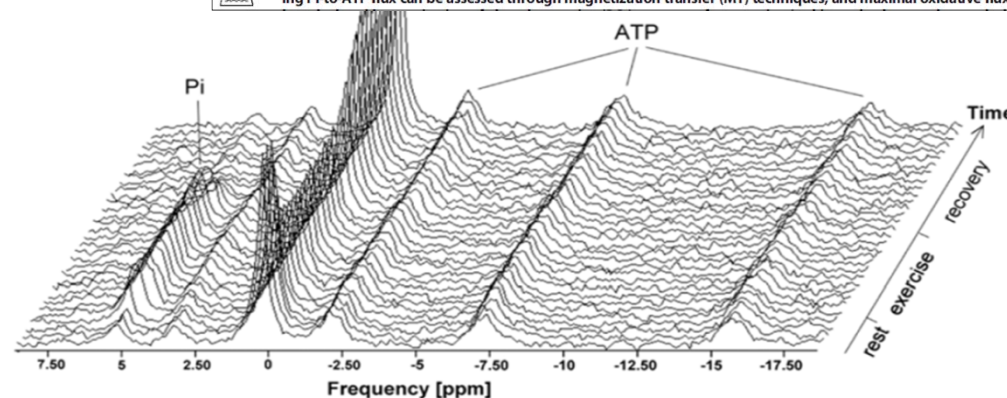
Research article **NMR**
IN BIOMEDICINE

Received: 19 November 2012, Revised: 24 May 2013, Accepted: 6 July 2013, Published online in Wiley Online Library: 16 August 2013
(wileyonlinelibrary.com) DOI: 10.1002/nbm.3008

Interrelation of ^{31}P -MRS metabolism measurements in resting and exercised quadriceps muscle of overweight-to-obese sedentary individuals

Ladislav Valkovič^{a,b}, Barbara Ukropcová^{c,d}, Marek Chmelík^a, Miroslav Baláz^c, Wolfgang Bogner^a, Albrecht Ingo Schmid^{a,e}, Ivan Frollo^b, Erika Zemková^f, Iwar Klimes^c, Jozef Ukropec^c, Siegfried Trattnig^a and Martin Krššák^{a,g*}

Phosphorus magnetic resonance spectroscopy (^{31}P -MRS) enables the non-invasive evaluation of muscle metabolism. Resting Pi-to-ATP flux can be assessed through magnetization transfer (MT) techniques, and maximal oxidative flux (Q_{max}) can

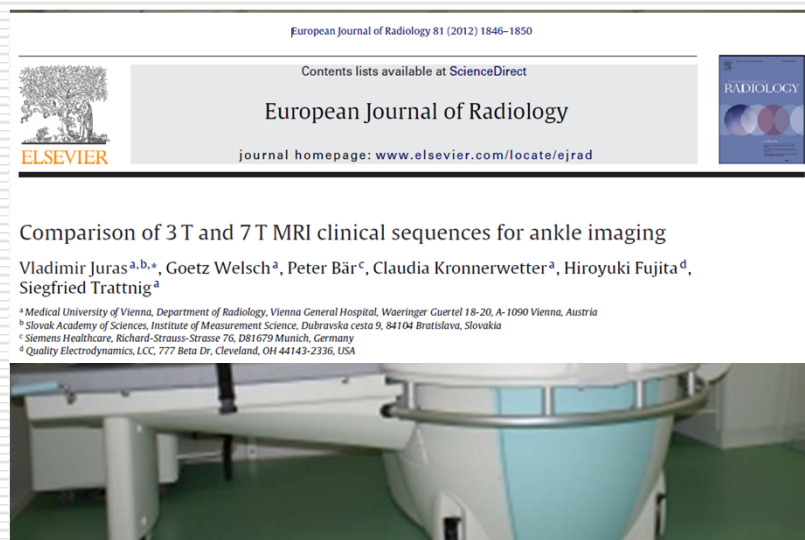


Co-operation with MR Center, Medical University of Vienna, Austria.

Time evolution of the ^{31}P spectrum at rest, during exercise and consecutive recovery.

MRI Diagnostics of Biological Tissues Using Nano-particles

NMR imaging device from ESAOTE
in the National Center for NMR
material imaging



Imaging of degenerative damage
of the Achilles tendon

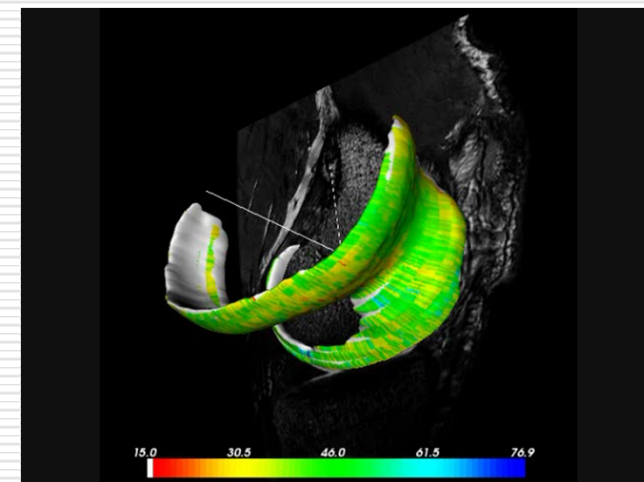
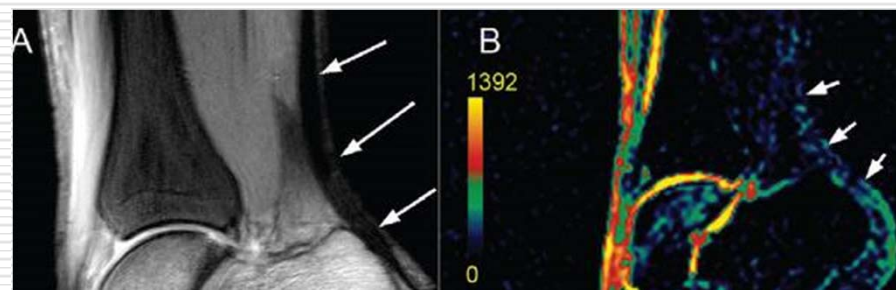


Image of a cartilage transplant with
contrast agent based on nano-
particles. Knee kinematics.



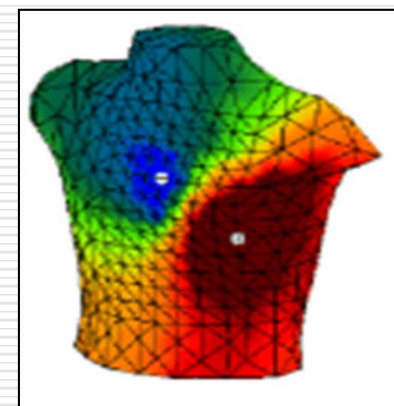
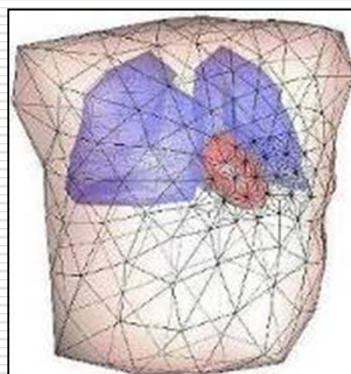
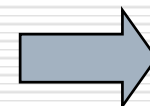
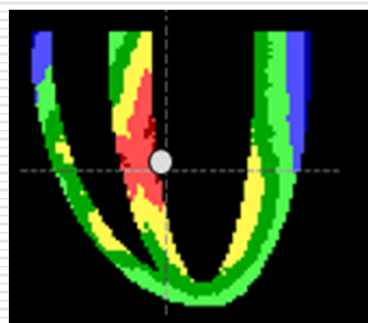
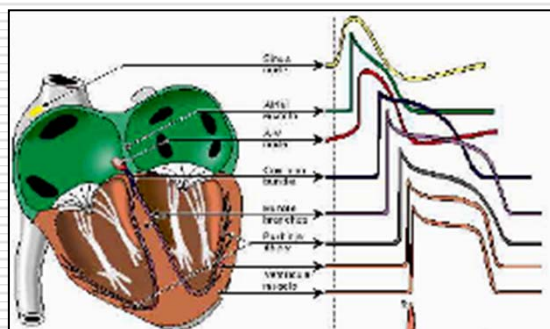


Department of Biomeasurements

- ❑ Realistic modeling of the heart activation to explain variations of the measured cardiac electrical field
- ❑ Research of inverse methods for non-invasive assessment of local cardiac pathologies based on models of the cardiac electric generator
- ❑ Development of advanced technologies for multichannel measurement of the cardiac electrical field

Cardiac Electrical Field Modeling

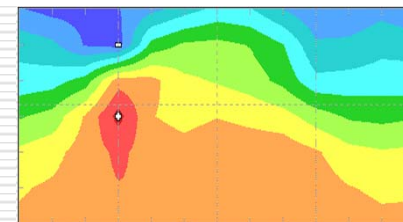
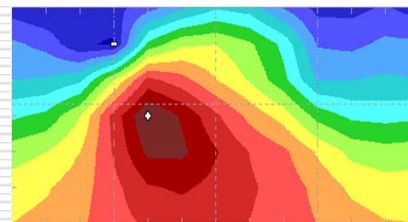
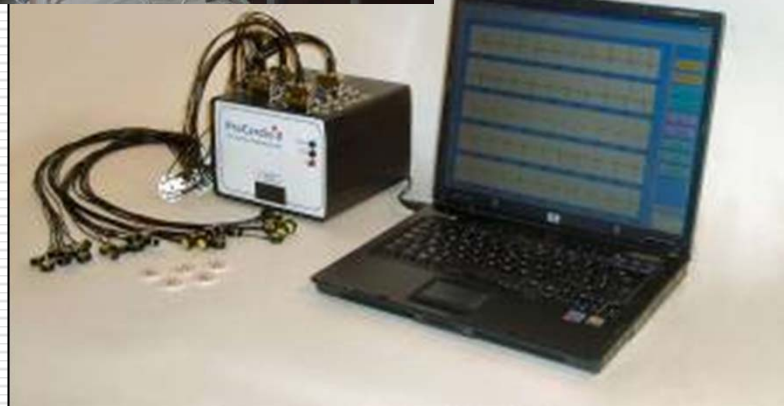
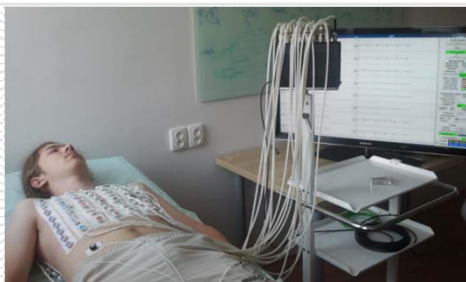
Based on the knowledge of the properties of the heart as a generator of the electrical field, heart activation and cardiac potentials on torso as inhomogeneous conductor can be modeled.



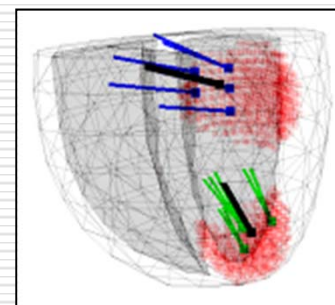
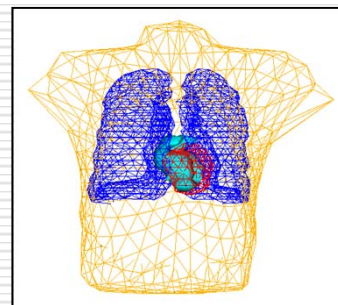
Noninvasive cardiac diagnostics based on inverse solutions

Body surface potential mapping with up to 128 recorded ECG signals from the chest and their imaging as potential maps helps in more precise diagnostics of cardiac diseases.

ProCardio 8 mapping system

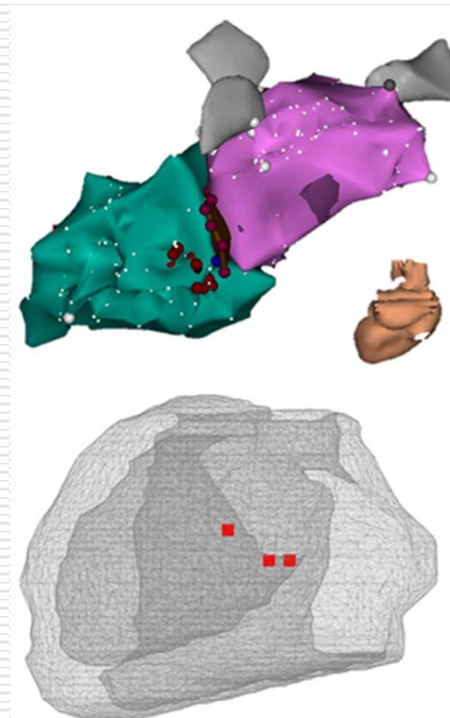
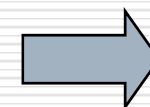
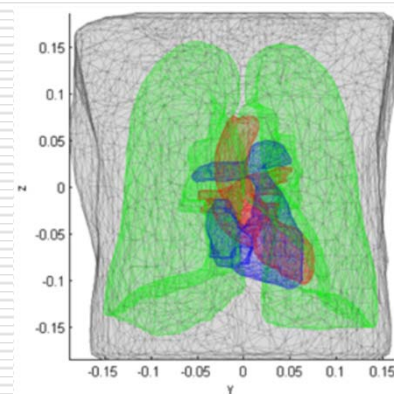
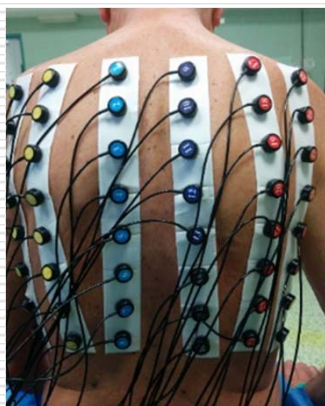


BSPM difference between normal and ischemic surface potentials and CT are used for noninvasive localization of one or two ischemic lesions



Noninvasive cardiac diagnostics based on inverse solutions

- Identification of arrhythmia sources in the heart by the ECG mapping, tomographic imaging and mathematical calculation of the inverse solution.





Other Activities

❑ Scientific journal Measurement Science Review

ISSN 1335 – 8871

supported by Slovak National Committee IMEKO

Accessible at:

<http://www.measurement.sk>

Since 2008 published and accessible at:

Walter de Gruyter GmbH, Berlin

<http://www.degruyter.com/view/j/msr>

Cited in databases:

Web of Science, Thomson Scientific SSCI,
Scopus, EBSCO and **30 others...**

(0.969 – IF 2015)

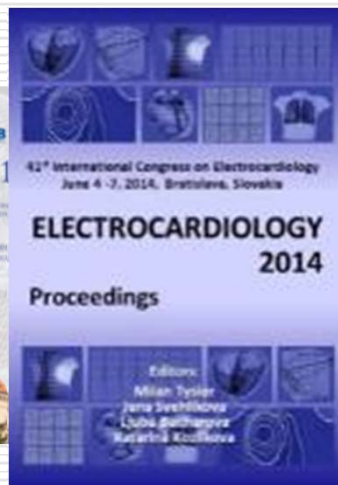
H Index: 13



Other Activities

□ International Conferences

- Measurement 2013, 2015
- ETAT 2013, 2015 IEEE EMBS Summer School on Telemedicine
- 41st International Congress on Electrophysiology 2014
- Probastat 2015,





PhD study

- Accredited program of the doctoral study:
 - **5.2.54 Measurement technology**
 - together with FEIIT SUT in Bratislava
 - since 2006 (reaccredited in 2009, 2016)

Popularization of Research

Night of Researchers
Bratislava,
September 2012 - 2015



Popularization of Research

Open door days in IMMS SAS November 2012 - 2015



Ústav merania SAV
Dubravská cesta 9, 841 04 Bratislava
www.um.sav.sk

dovôľte si Vás pozvať na

Deň otvorených dverí
v utorok 10.11.2015
V rámci Týždňa vedy a techniky na Slovensku

Predstavenie ústavu a jeho vybraných výskumných zmerov

Čas: od 9:30 do 10:00
Miesto: zasedacia izba merania SAV, 4 poschodie

- Ústav merania a jeho výskumné aktivity (doc. RNDr. Viktor Vilkovsky, CSc., zástupca riaditeľa UM SAV)

Prehliadky laboratórií, predstavenie nových technológií a ukážky výsledkov

Čas: od 10:00 do 15:00, začiatok návštev v jednotlivých laboratóriách kašľu celú hodinu
Miesto: Laboratóriá podľa vlastného výberu:

- Laboratórium Nádružného centra (NCC)** (prízemie č. 000-013)
V laboratóriách sa uskutočňujú výskumy a praktická ukážka činnosti MR výskumných tomografů a prvých a rozširovaných magnetů (prof. Ing. Frída, DrSc., Ing. Andri, CSc.).
- Laboratórium röntgenovej mikrotomografie** (prízemie č. 002)
V laboratóriu budú prezentované metódy röntgenovej mikrotomografie vo výskume v materiálových vedách, elektrotechnike, mineralógii, biológii a ochrane kultúrneho dedičstva (RNDr. Han, PhD.).
- Laboratórium elektrónovej mikroskopie** (prízemie č. 007a, pracovisko UMMS SAV)
V laboratóriu budú predstavené špičkový mikroskop JEM-1000F a ukážky sa vykonávajú možnosť realizácie elektrónovej mikroskopie v materiálovom výskume (Ing. Tošák, PhD.).
- Laboratórium na meranie slabých magnetických polí** (odbočky z vrtnice ústavu)
V ukážkovom laboratóriu umiestnenom v lase pri ústave budú vyvetrené možnosti merania extrémne slabých magnetických signálov (Mgr. Štrábov, PhD.).
- Laboratórium biomeraní** (5. poschodie č. 506)
Meranie a modelovanie aktivity srdca, merania a analýzy biosignálov z viacerých ľudských orgánov. Využitie princípov a ukážky merania (Ing. Šušťáková).
- Laboratórium oddelenia teoretických metód** (5. poschodie č. 508)
Ukážky merania a analýzy EEG signálu (Mgr. Teplár, PhD.).

Kontakt a informácie:
Sekretariát ústavu: Eva Bukavcová, tel: 02/5477 4033, fax: 02/5477 5943, e-mail: umc@um.sav.sk
Z kapacity ústavu prosíme pre skupinovú návštevu vopred dohodnúť čas a program návštevy.

Popularization of Research

Sparkling Science Conferences in IMS SAS Bratislava since 2011

The Austrian - Slovak conference for talented students of the grammar schools in Austria and Slovakia.

The conference has been attended by students of the following schools:

- Bundesrealgymnasium in der AU, Innsbruck,
- Gymnasium Adolf-Pichler Platz, Innsbruck
- Akademisches Gymnasium Innsbruck
- Gymnázium Jura Hronca, Bratislava
- Gymnázium Grösslingová, Bratislava.



Sparkling Science 2013 | FEM_PERS Conference Bratislava | September 19, 2013

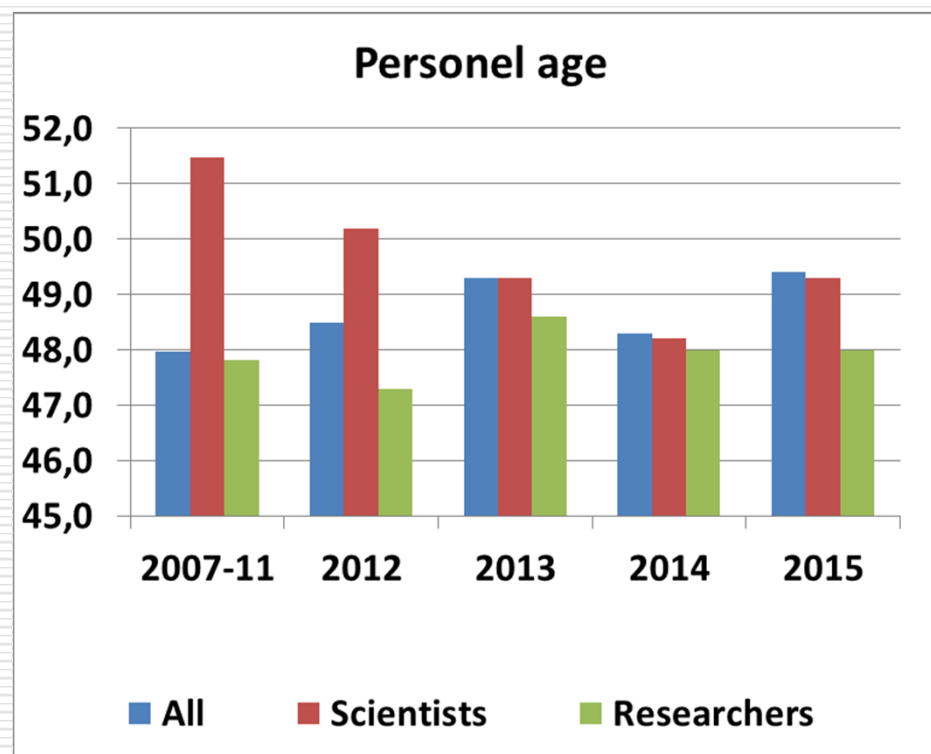
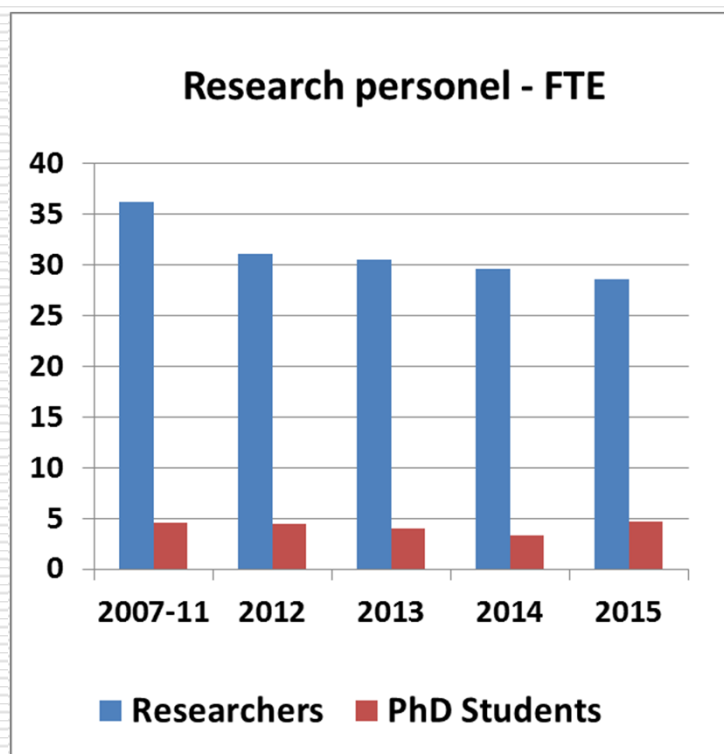
Popularization of Research

**Seminars and excursions for university students
April – May 2012-2015**

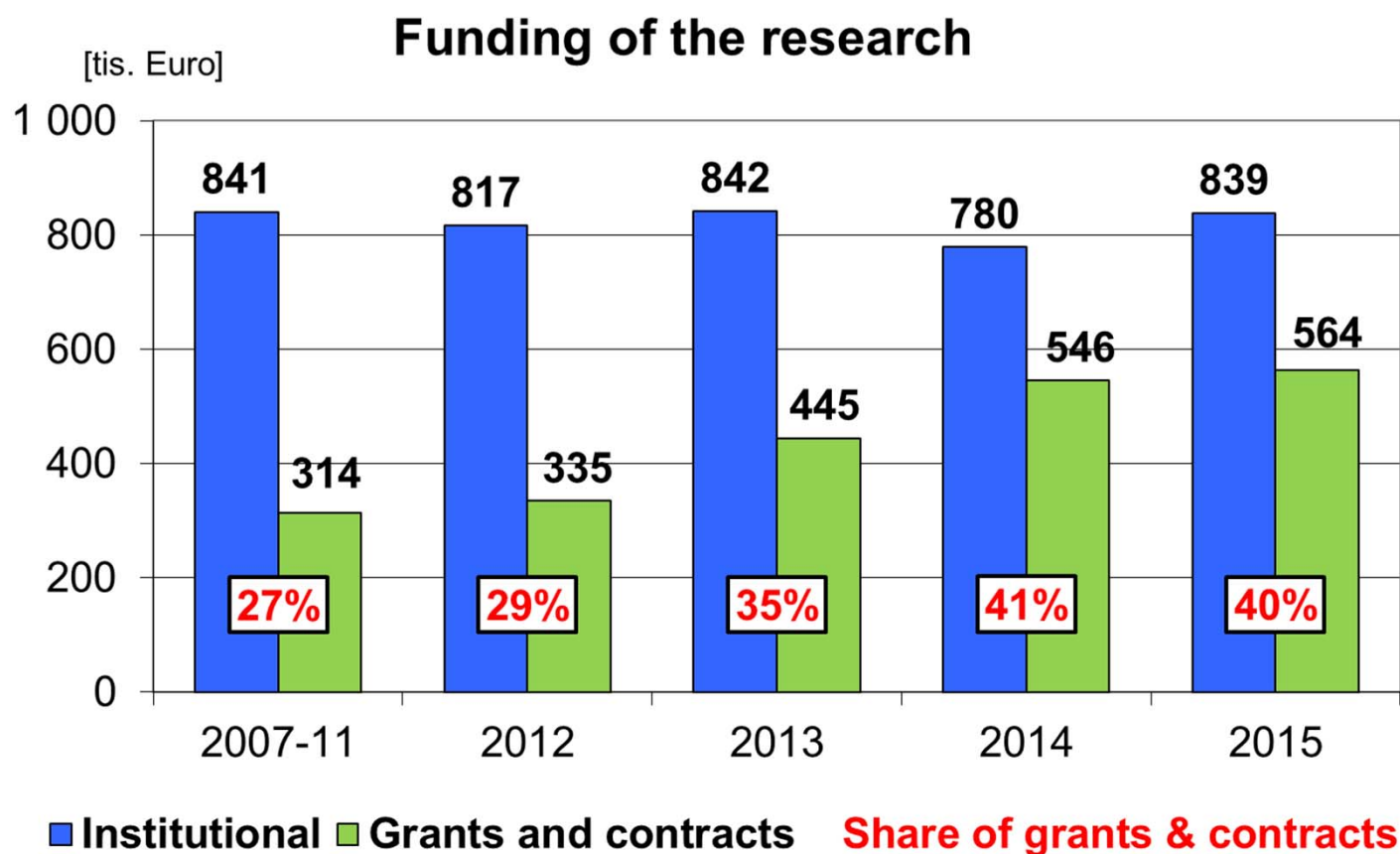
- Faculty of Electrical Engineering, ZU Žilina
- Faculty of Mechanical Engineering, TU Košice
- Faculty of Electrical Eng. & Information Technology, SUT Bratislava



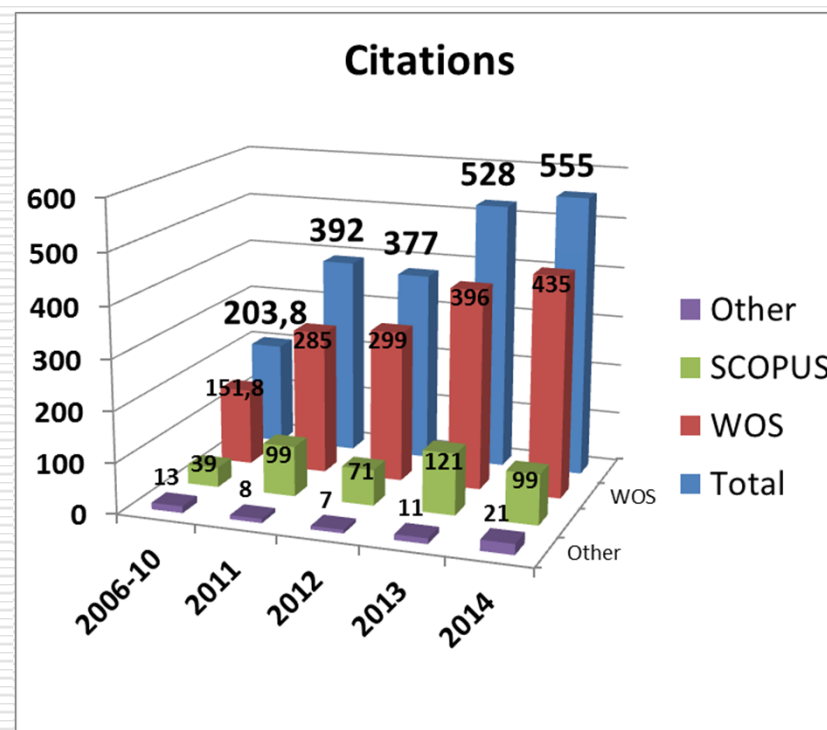
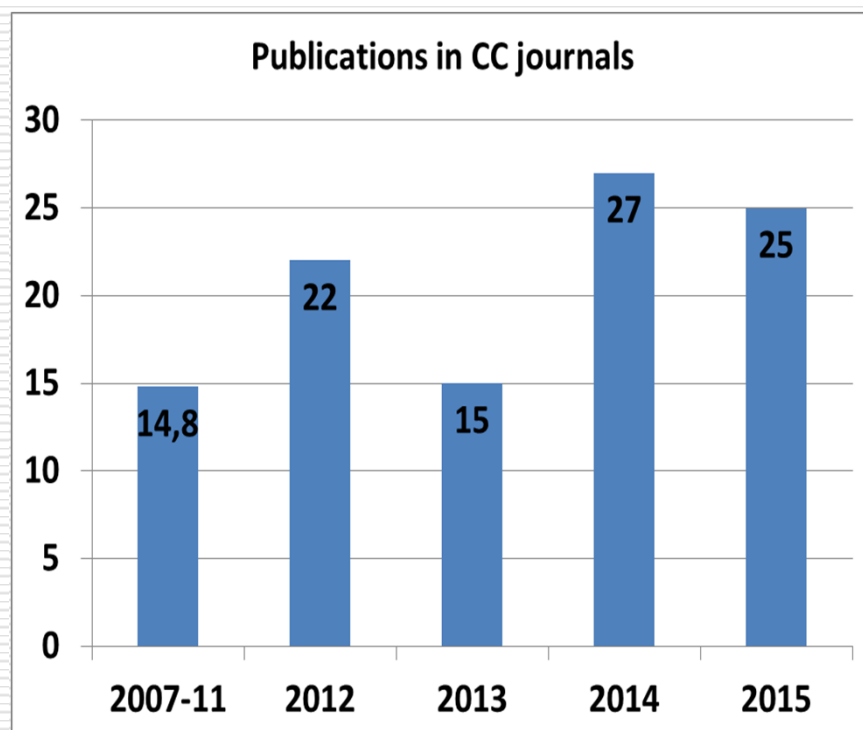
Personal development



Institute funding



Publications and citations



CC / year: 14.8 → 22.3 **150%**
FTE: 32.2 → 28.6

Citations/year: 204 → 555 **273%**



Future research orientation and strategy

- ❑ **Theoretical methods** for measurement science and metrology
 - Methods based on mathematical modeling and statistics
 - Dynamical systems
- ❑ **Optoelectronic measuring methods for NDT**
 - Active infrared thermography
- ❑ **Tomographic methods for material research and medicine**
 - X-ray microtopography
 - Special magnetic resonance imaging
- ❑ **Magnetometric methods**
 - Magnetic characterization of nanoparticles
 - Study of nitrogen vacancy centers
- ❑ **Biomeasurements**
 - Cognitive neuroscience
 - Model-based noninvasive diagnostics and therapy planning in ECG



Future research orientation and strategy

□ Cooperation

- Within European multilateral projects (COST, Horizon 2020 ?)
- Bilateral international cooperation
- Cooperation on national level
- Cooperation in applied research with partners from industry and medicine



Future research orientation and strategy

□ Running projects:

- COST 2012-16: Colour and Space in Cultural Heritage
- COST 2014-18: Origins and evolution of life on Earth and in the Universe
- COST 2014-18: EU network for innovative uses of EMFs in biomedical applications
- APVV 2013-16: The development of a diagnostic tool for quantitative MRI imaging of biogenic iron in clinical practice
- APVV 2013-16: Brain-computer interface with robot-assisted training for rehabilitation
- APVV 2015-18: Noninvasive localization of ectopic arrhythmias of heart ventricles
- APVV 2015-19: Physical non-destructive methods for complex testing and analysis of cultural heritage artefacts.
- APVV 2016-19: Research of comparative imaging methods based on magnetic resonance for diagnostics of neurological and musculoskeletal diseases
- APVV 2016-20: Advanced statistical and computational methods for measurements and metrology

- Additional 8 VEGA projects



Future research orientation and strategy

□ Submitted projects:

- EU 2017-20: Research & development center for medical informatics (Goldman a.s.)
- EU 2017-22: Advanced material research of new generation of multi-purpose terahertz and x-ray detectors (Colosseo a.s.)
- EU 2017-22: Complex research of impact of selective and low-level electromagnetic fields on the development of oncogenous diseases and population health (VUJE a.s.)
- APVV 2017-21: Research of magnetic iron forms in development aging-associated cardiovascular diseases and behavioural disorders (Inst. Of Normal & Pathological Physiology SAS)
- APVV 2017-21: Enhancing cognition and motor rehabilitation in mixed reality (Faculty of Mathematics and Physics, Comenius University)

- Additional 4 VEGA projects



Thank you for your attention !

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