

## **Questionnaire**

### **Summary of the main activities of a scientific Organisation of the Slovak Academy of Sciences**

*Period: January 1, 2007 - December 31, 2011*

#### ***I. Formal information on the assessed Organisation:***

##### **1. Legal name and address**

Ústav merania Slovenskej akadémie vied  
Institute of Measurement Science, Slovak Academy of Sciences  
Dúbravská cesta 9, 841 04 Bratislava 4

##### **2. Executive body of the Organisation and its composition**

Directoriat	name	age	years in the position
director	Assoc. Prof. Milan Tyšler, PhD.	60	6
deputy director	Assoc. Prof. Viktor Witkovský, PhD.	48	6
scientific secretary	Ján Maňka, PhD.	50	6

##### **3. Head of the Scientific Board**

Assoc. Prof. Viktor Witkovský, PhD.

##### **4. Basic information about the research personnel**

- i. Number of employees with a university degree (PhD students excluded) engaged in research and development and their full time equivalent work

capacity (FTE) in 2007, 2008, 2009, 2010, 2011 and average number during the assessment period

ii. Organisation units/departments and their FTE employees with the university degree engaged in research and development

Research staff	2007		2008		2009		2010		2011		average	
	No.	FTE	No.	FTE	No.	FTE	No.	FTE	No.	FTE	No.	FTE
organisation in whole	59	32,50	58	37,40	58	37,26	54	36,82	49	32,21	55,60	35,24
Department of Optoelectronic Methods	12	8,00	12	8,50	11	9,53	9	7,40	6	6,00	10,00	7,89
Department of Magnetometry	13	7,55	15	8,60	14	9,00	11	7,70	8	8,00	12,20	8,17
Department of Theoretical Methods	16	7,20	17	9,00	15	7,43	14	9,52	16	8,16	15,60	8,26
Department of Imaging Methods	12	4,90	8	5,50	9	4,60	10	6,00	10	5,30	9,80	5,26
Department of Biomeasurements	6	4,85	6	5,80	9	6,70	10	6,20	9	4,75	8,00	5,66

## 5. Basic information on the funding

i. Total salary budget<sup>1</sup> of the Organisation allocated from the institutional resources of the Slovak Academy of Sciences (SAS) in 2007, 2008, 2009, 2010, 2011 and average amount for the assessment period

Salary budget	2007	2008	2009	2010	2011	average
total salary budget (millions of EUR )	0,542	0,572	0,592	0,611	0,580	0,579

## 6. URL of the Organisation's web site

Slovak version: <http://www.um.sav.sk/sk/>

English version: <http://www.um.sav.sk/en/>

<sup>1</sup> Objem mzdových prostriedkov bez odvodov do poisťovní so započítaním sumy miezd pracovníkov THS, ktorú organizácii poskytne ETO Úradu SAV. Rozpočet v Sk prepočítajte na eurá podľa konverzného kurzu 1€ = 30,126. (Podobne aj v ďalších tabuľkách.)

## **II. General information on the research and development activity of the Organisation:**

### **1. Mission Statement of the Organisation as presented in its Foundation Charter**

1. The Institute is specialised to basic research in measurement science and mathematical methods for processing of measured data. It is concentrated to development of new methods for measurement, modelling and computer processing of selected physical quantities, properties of materials and parameters important in biomedicine, using laws of physics, mathematics and biophysics. The scope of the research falls within technical and natural sciences and is oriented mainly to electrical engineering, automation and control systems, mechanical and material engineering and mathematical sciences.
2. The Institute is oriented to design of methods and measuring systems dedicated to non-standard measurement problems in the research, industry and economical and social sphere. It develops and implements unique measuring systems as materialised result of the scientific research carried out in the Institute.
3. The Institute offers advisory and other expert services related to the main activities of the organisation.
4. The Institute performs postgraduate education governed by valid legislative regulations.

The Institute publishes results of its scientific research in periodic and non-periodic press. Publishing of own periodic and non-periodic titles obeys the decisions of the Presidium of the Slovak Academy of Sciences.

### **2. Summary of R&D activity pursued by the Organisation during the assessed period, from both national and international aspects and its incorporation in the European Research Area (max. 10 pages)**

In concordance with its Foundation Charter, research activity of the Institute of Measurement Science SAS encompasses following main domains of basic and applied research:

- Measurement theory, mathematical and statistical methods for processing of measured data;
- Principles and systems for measurement of selected physical quantities;
- Measuring methods and systems for biomedicine, mathematical and computer modelling of biological structures and processes, methods for biosignal processing;
- Design of methods and measuring systems for non-standard problems of measurement in science and industry, technologies for non-destructive or non-invasive material testing and diagnostics.

The research activities of the Institute are organised within 5 scientific departments: Department of Optoelectronic Measuring Methods, Department of Magnetometry,

Department of Theoretical Methods, Department of Imaging Methods and Department of Biomeasurements. In following paragraphs, main research activities of the departments during the assessment period will be introduced and their role and positions in national and international scientific cooperation will be outlined.

Research in the **Department of Optoelectronic Measuring Methods** has been focused during the assessed period in these four main areas:

- X-ray microtomography
- Active and passive infrared thermography
- Methods and tools of continuous measurement of the tilt of reactor vessels in nuclear power plants
- Use of non-destructive optical methods for preserving the cultural heritage

**X-ray microtomography** is a novel topic in the Department's research activities. The crucial point for introduction of this theme was establishment of the Laboratory of X-ray microtomography in the IMS SAS in the frame of the EU funded project CEKOMAT. The Laboratory is equipped with microtomograph Nanotom 180 with powerful computer cluster for 3D image reconstruction and computer workstation with rendering and image processing software.

Research in the area of X-ray microtomography is aimed at the development of optimal methodologies of measurement and non-destructive testing of objects and materials mainly in the area of material research, mineralogy, palaeontology, geology, electronics, microelectronics, micromechanics, archaeology and preserving of cultural heritage. Comparing to standard CT the new quality of microtomographic measurement was allowed by significant increase of measurement resolution down to 1 micrometer. It enabled principally new non-destructive qualitative and quantitative analysis of internal structure of objects and materials under study. This research is state of the art and has many applications in science and industry. The research was carried out in the frame of the VEGA project 2/0201/10 "*Progressive methods of measurement and non-destructive testing - active infrared thermography and X-ray microtomography*".

**Active and passive infrared thermography** is another important topic of the Department's research activities. An active thermographic method using transient heating by the use of infrared radiation was proposed. The research team theoretically analysed and practically developed and verified a procedure for optimizing the method of active infrared thermography using modelling of the heat transfer in inhomogeneous media by the Finite Element Method. It was proposed to use thermal contrast as the most suitable optimization criterion of this method. Achieved theoretical results were qualitatively and quantitatively verified in experiments using the results of the laboratory and in situ measurements. Results of basic research are used to optimize the method of active infrared thermography that finds its use as a non-destructive testing method for detecting hidden defects in materials, but also in cultural heritage objects. The research was carried out in the frame of the VEGA project 2/0201/10 "*Progressive methods of measurement and non-destructive testing - active infrared thermography and X-ray microtomography*".

**Methods and tools for continuous tilt measurement of reactor vessels in nuclear power plants (NPPs)** is important part of the Department's research activities. Research was focused on the development of new methods and instruments devoted to automated and continuous measurement of the tilt of reactor

vessels in NPPs. Principles of damped physical pendulum and hydrostatic levelling with state of the art optical sensing were used. Evaluation of measured data in each sensor and communication with the master computer are carried out by microcomputers.

Results of this research serve for increasing safety of Slovak nuclear power plants and are applied in several measuring systems in NPP Jaslovské Bohunice and NPP Mochovce. Recently a new improved measuring system for the third and fourth reactor of the NPP Mochovce has been developed.

Research of **non-destructive optical methods for preserving the cultural heritage** was focused on the development and application of non-destructive optical methods for the use in the area of preserving the cultural heritage. During the assessed period, the main emphasis was put on the improvement of the method of infrared reflectography, the method of ultraviolet fluorescence and the method of active infrared thermography. The main improvements were based on enhanced digital image processing and improvements of the measuring / testing systems. Results of this research are used in cooperation with restorers (Chamber of restorers) for testing of cultural and historical artefacts. Infrared reflectography was used for visualisation of underdrawings in gothic church table paintings, ultraviolet fluorescence was used for distinction of newer overpaintings in old pictures and active infrared thermography was used for testing of defects in walls with frescos and wall-paintings.

Within **international cooperation** with Nanoelectronics Research Institute in Tsukuba, Japan, **optical methods and devices for nanoelectronics** were investigated. Method for diffraction of optical radiation on the surface of tested materials using special newly developed optics (hemispheric lens with high refraction index, image channel and a pair of ellipsoid mirrors) and dedicated measuring software were designed, experimentally verified and a Scatterometer device for fast measurement of the distribution function of reflected light was developed.

In collaboration with the Joint Institute for Nuclear Research in Dubna, the design of **new methods and electronic apparatus for accelerator steering** during the process of intense heavy ion bundles and polarized nuclei generation have been developed. These methods and apparatus have been aimed at the research of a mixed phase of nuclear matter and investigation of polarization phenomena in collisions of ions with energy up to 11 GeV.

The research of the Department **of Magnetometry** was focused at the following main areas:

- basic research in the field of biomagnetism based on non-invasive SQUID magnetometric methods and systems,
- material research and development of technologies for particular oxide materials preparation, high temperature superconductors and nanomaterials, especially based on iron and vanadium oxides,
- development of devices and technologies for special magnetometric measurements.

In the field of **biomagnetism** the research was aimed at non-invasive method of determination of the Fe content in the human liver and tissue by SQUID

biomagnetic measuring system (modification of an original SQUID system with 2-nd order gradiometer designed and prepared by the IMS SAS). The method based on using electronic model of the measured object was designed. The results have been compared with measurements using electrothermal atomic absorption spectrometry (ETAAS) performed at Faculty of Natural Sciences, Comenius University. At present, the SQUID biomagnetic measuring system enables to quantify the Fe content in the liver, mainly in the range of higher concentrations (higher than  $0.5 \text{ mg}_{\text{Fe}}/\text{g}_{\text{liver}}$ ), i.e. iron overload. Special attention has been devoted to the effect of the intracellular environment on the accuracy of the Fe content determination. This environment was simulated by liquids (epoxy and dimethylpolysiloxane) with two various viscosities and the liver iron was simulated by dispersed  $\text{Fe}_3\text{O}_4$  particles. The results give useful information for study of iron physiological processes and timing of the magnetizing processes and for interpretation of magnetic relaxation measurements. Two measuring methods have been designed: 1) Electronic phantom for measurement of the volume magnetic susceptibility enabling to determine the ferritin content in the liver from data measured by a biosusceptometer, 2) Complex model of the chest and abdomen for the calibration of the biosusceptometer, enabling to measure the Fe concentrations in different-sized liver models and simultaneously to observe the air influence in the lungs. Using these models it is also possible to determine the influence of liver position change on measurement uncertainty. The measuring method has been verified on models and experimentally tested on four patients. The results were in a good agreement with the values of Fe concentration obtained by MRI examinations of the livers of these persons in the Radiodiagnostic Clinic, Academician Ladislav Derer Hospital, Bratislava (correlation  $r = 0.9$ ).

In **material research** the RE-Ba-Cu-O-based polycrystalline and textured (RE = Y, Eu, Sm, Gd, Nd) and thin-films based on YBCO and bulk Tl(Hg)-Ba-Ca-Cu-O superconductors were studied, as well as the regulation of their properties through change of initial precursors, conditions of homogenization, calcination and synthesis. Effects of cation non-stoichiometry and doping by cerium of basic RE-Ba-Cu-O superconductors were examined. Procedures and technological parameters optimizing the volume of the superconducting phase and critical characteristics reflected in diffraction, transport, and magnetization  $M(H)$  measurements were determined. For single-domain samples preparation by the top-seed melt-textured-growth method, necessary precursors and texturation growth parameters were prepared and analysed. In magneto-optical imaging and polarization microscopy the original cryogenic module (indirectly cooled  $\text{LN}_2$  optical cryostat) has been realised.

The scandium doped  $\text{YBa}_2\text{Cu}_3\text{O}_y\text{-Sc}_2\text{O}_3$  system was investigated, prepared by solid state reaction from stoichiometric mixtures of oxides and  $\text{BaCO}_3$  with a nominal composition of  $\text{YBa}_2(\text{Cu}_{3-x}\text{Sc}_x)\text{O}_y$ . The solubility limit of Sc in solid solution of  $\text{YBa}_2(\text{Cu}_{3-x}\text{Sc}_x)\text{O}_y$  was determined to be about  $x = 0.15$ . The superconducting phases were presented up to nominal  $x=1.0$ . The main excess phase(s) could be represented by a family Ba-Cu-(Y)-Sc of  $\text{Ba}_3\text{Cu}_3\text{Sc}_4\text{O}_{12}$  phase which is paramagnetic. In cooperation with the Polymer Institute of the SAS the composite material - superconductor (YBCO) and polyethylene (Bralen RA 2-19) – has been prepared a tested.

In the field of **development of nanotechnologies** for the nano-sized  $\text{Fe}_3\text{O}_4$  powders and suspensions (using acetone,  $\text{dH}_2\text{O}$ , etc.) special attention

was devoted to their magnetic properties using the SQUID magnetometer QD MPMS XL-7 (gained via EU Structural Funds, project CENTE II). In cooperation with the Polymer Institute of the SAS the superparamagnetic nanoparticles  $\text{Fe}_3\text{O}_4$  covered by citric acid were prepared by the micro emulsion method. The mean hydrodynamic diameter of the particles was  $\sim 35$  nm. Their blocking temperature  $T_B \sim 55$  K was estimated using a measurement of zero-field-cooled and field-cooled magnetization-temperature dependences.

In **mechanochemical synthesis** the Department has been focused on the  $\text{TiO}_2$ ,  $\text{V}_2\text{O}_3$ ,  $\text{Na}_2\text{Ti}_6\text{O}_{13}$  and  $\text{SnO}_2$  for their well-known application in the self-cleaning processes or in the Li-ion batteries with large storage capacity and long life operation. The mechanochemical synthesis of nanoparticles represents one of the low cost industrial-scale methods.

In cooperation with partner academic and university institutions a novel approach to the preparation of  $\text{Na}_2\text{Ti}_6\text{O}_{13}$  nanobelts by combined mechanochemical-molten salt synthesis has been developed. This method gives a new and simple approach for the synthesis of  $\text{Na}_2\text{Ti}_6\text{O}_{13}$  nanostructures. The method seems to be general; it can be used for synthesis of different kinds of nanocrystals. At the same manner, titania nanopowders were synthesized mechanochemically using  $\text{TiCl}_4$  and  $(\text{NH}_4)_2\text{CO}_3$  or  $\text{TiCl}_4/(\text{NH}_4)_2\text{CO}_3$  and  $\text{Na}_2\text{SO}_4\text{-Na}_2\text{SO}_4\cdot 10\text{H}_2\text{O}$  as precursors followed with post-annealing in the temperature range  $150\text{--}850$  °C. The mechanochemical synthesis represents a simple method for the preparation of  $\text{TiO}_2$  nanopowders characterized with controlled nanoparticle size and photoactivity. The mechanochemical methods have been also used for preparation of 9-13 nm  $\text{VO}_2$  nanopowders and of nanocrystalline  $\alpha\text{-Al}_2\text{O}_3$  powders from basic polyaluminium chloride gel. Also some problems of the effects of high energy milling parameters on the size distribution of the Fe, Ni a  $\text{Fe}_3\text{O}_4$  powders have been studied.

Within the projects, the Department had **scientific cooperation** with a number of institutions in Slovakia and abroad. In Slovakia these were Faculty of Medicine and Faculty of Natural Sciences, Comenius University in Bratislava, Institute of Physical Chemistry and Chemical Physics, Faculty of Chemical and Food Technology, Slovak University of Technology in Bratislava; Institute of Materials Science, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology.

Among the international contacts the most important was bilateral scientific cooperation with the Research Group on Solid State Chemistry and Ceramic Superconductors, Department of Inorganic and Physical Chemistry, University of Ghent that exists since 1999. The cooperation is oriented to materials research on selected oxide materials, especially high temperature superconductors of the REBaCuO type. Most of the studied materials have been prepared by the IMS SAS and their characteristics were studied in Ghent. The partial tasks of optimization of technological parameters of developed precursors and study of their effects on the resultant properties of studied materials have been solved. The results of precursors study were utilized in investigation of the effects of RE and Ba cation non-stoichiometry in REBCO superconductors (RE = Eu, Gd,), or the addition of  $\text{CeO}_2$  into  $\text{REBa}_2\text{Cu}_{3-x}\text{Ce}_x\text{O}_{7-\delta}$  and  $\text{Eu}_{1-x}\text{Ce}_x\text{Ba}_2\text{Cu}_3\text{O}_{7-\delta}$  materials (RE = Y, Eu, Sm). Some tasks for increasing of the current density of the high temperature superconductors were solved. The effects of chemical doping using EuBaCuCeO-4211 precursors were investigated. This resulted in formation of nanosized pinning magnetic field centres in Eu-Ba-Cu-O.

Basic and applied research in the **Department of Theoretical Methods** was oriented into the area of applied mathematics, focused on development of new methods and advanced applications in the field of measurement science, metrology, and in particular in the area of mathematical statistics, nonlinear dynamical systems and applied informatics. Emphasis was placed on problems of measurement, including proper design of experiments, selection/development of mathematical statistical models, methods and algorithms for evaluation and interpretation of experimental data in different interdisciplinary areas of technical and biomedical research.

In basic **research in the area of mathematical statistics**, new original results have been achieved in the theory of nonparametric methods, including new methods and results about the properties of spatial median and also an original method for construction of confidence intervals for ratios of variances in the case of several populations, if the standard normality assumption is not fulfilled. An extensive original scientific monograph on nonparametric methods has been published by VEDA – Publishing House of the Slovak Academy of Sciences. The monograph provides an ample, well-knit and well-structured exposition of the mathematical statistical theory of nonparametric methods with strong emphasis also on their practical use. In addition to classical procedures, it contains new original results in inference, in location-scale models, random blocks and multiple comparisons, and simultaneous confidence intervals for ratios of variances.

New results have been achieved in developing models, methods and algorithms for proper **analysis of measurement results** and uncertainty analysis in metrology. New procedure based on generalized inference method have been suggested for making statistical inference on the model parameters based on quantised (digitised) observations. New methods and algorithms have been suggested and tested for the common mean problem known in interlaboratory comparisons in metrology (including the inter- and intra- laboratory random effects as well as the systematic effects). New results have been achieved also for the univariate linear calibration via replicated errors-in-variables model as well as for the linear comparative calibration with correlated measurements. Original methods have been suggested for construction of the simultaneous tolerance intervals for normal linear regression and for construction of confidence intervals and regions for variance components in the linear mixed model with two variance components.

In the area of **nonlinear dynamical systems**, the research was focused on investigation of the reconstruction of the brain dynamics built in multi-dimensional state spaces, in particular on the following three problems: (i) brain response to audio-visual stimulation (AVS), (ii) search for signs of relaxation in EEG and (iii) automatic sleep classification. Our research in the domain of theory of chaos and fractals brought new insight into the complexity of brain dynamics. In the case of many, seemingly complex, real processes, the estimate of their fractal dimension is low, but this need not approve that they can be modelled by small number of nonlinear differential equations with chaotic dynamics. Often, the low fractal dimension is only a demonstration of a special class of stochastic systems which generate scale-invariant structures similar to fractals. While the exponential decrease of power spectrum in the area of high frequencies is typical for chaotic signals, stochastic behaviour has power spectrum of power-law decay. In our study,



power-law decay prevailing over the exponential falling off was established from the EEG spectrum. Consequently, the hypothesis of presence of scale-invariant fractal-like structures in brain dynamics should be preferred rather than the suggestion of deterministic chaos. A special attention was devoted to problems of predictability of time series. The nonlinear prediction based on the reconstruction of dynamic properties of the system proved to be successful.

Within the recent decade, the research revealed the significance of biologically inspired models for **applied informatics** and in particular for representation and processing of visual data. In particular, the Hierarchical Temporal Memory (HTM) Bayesian network has become attractive as a possible large-scale model of basic functions of the neocortex. In the tasks of visual object classification a new methodology of the construction of the network architecture was proposed, novel generators of training sequences were developed. The algorithm of optimum estimation of the spatial quantization represents another original contribution. The operation of inference in the HTM network was optimized on the basis of maximization of entropy and/or likelihood. The optimised versions of the HTM were benchmarked with different classification methods and it appeared that this bio-inspired model has a great potential for applications.

Expertise and acknowledged professional competence of the department's research staff allowed participating and effectively contributing in several **advanced applications** in different interdisciplinary areas of technical and biomedical research.

The Department had **intensive scientific cooperation** with research partners both in Slovakia and abroad (e.g. Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava, Mathematical Institute of the SAS, Bratislava, Faculty of Mathematics and Physics, Charles University in Prague, Institute of Computer Science, Academy of Sciences of the Czech Republic, Prague, Faculty of Natural Sciences, Palacky University, Olomouc, CZ, Faculty of Natural Sciences, Masaryk University in Brno, Austrian Institute of Technology GmbH, Seibersdorf, Austria, Medical University Innsbruck, Austria, Louisiana State University Health Sciences Centre, School of Public Health, New Orleans, USA, National Institute of Standards and Technology (NIST), Gaithersburg USA, Physikalisch-Technische Bundesanstalt (PTB), Braunschweig Germany). Within the international cooperation the research team has been involved in the EU project BAMOD - Breath-gas analysis for molecular-oriented detection of minimal diseases, a project within the framework of the specific research and technological development programme integrating and strengthening the European Research Area. In cooperation with international partners the Department has been incorporated in participation and/or preparation of several bilateral and multilateral projects, including projects focused on modern methods for evaluation of electrophysiological signals, development of statistical toolbox for analysis of exhaled breath data, carcinoma screening based on exhaled breath, phenotyping of genome-based biomarkers for patient stratification using exhaled breath diagnostics and genome-based biomarkers for patient stratification and pharmacogenomic strategies.

Basic research in the **Department of Imaging Methods** was aimed at imaging of biological and physical objects using nuclear magnetic resonance (NMR) with low magnetic field of 0.1 Tesla and 0.18 Tesla. The main areas of the research were

- investigation of new imaging methods and special sensors,
- imaging of human articular cartilage,
- instrumentation for polarized helium lung imaging,
- imaging of macro- and microstructures for biomedical and material research,
- imaging using magnetic nano-particles.

New **imaging methods for biomedical and material research** with an orientation to diagnostics of human articular cartilage, based on Nuclear Magnetic Resonance, were developed. Using of these methods it is possible to assess the progress of the transplant cartilage human knee cure and in a post-operation period. The advantage of the methods is their non-invasibility. New method of NMR images quality testing, using physical and electromagnetic phantoms, increases the image quality. The method is suitable for imaging equipment and imaging methods testing with a high universality, stability and repeatability. New methods for artefacts reduction of NMR images further increased the image quality. Methods were tested on patients after transplantation of extremities, for brain activities investigation using functional diagnostic methods and by effects of stress evaluations. The method has also a perspective application in clinical laboratories oriented to the liver and other organ diagnostics.

Techniques of **magnetic materials imaging based on magnetic resonance**, using special sensors and homogeneous static magnetic field, can image very small changes of magnetic field in human organism, or also in-vitro of small physical samples. Series of new techniques of imaging of biogenic magnetite based on tests of relaxation processes after excitation has been developed. The new method of testing of weak magnetic materials has been experienced using the magnetic resonance. Essential condition for application of the proposed techniques is achieving the optimal homogeneity and stability of the static magnetic field. Suggested new procedure of the optimisation enabled fast and accurate setting of the homogeneity of the magnetic field in the target volume. The new method has been successfully tested in experiments using small samples. It can be applied in the subsequent research for examination of interactions between the magnetic field and a living organism as well as for research of new magnetic materials.

Within cooperation with Medical University of Vienna **new methods of artefact reduction in the images** were investigated. Enhancement of the quality of the images from Magnetic Resonance Imaging (MRI) was designed, experimentally tested and clinically validated. The focus has been put on the images biased by noise, geometrical distortions, moving and stress artefacts, and mostly on eliminating of magnetic field inhomogeneities causing geometrical distortions. Proposed methods have been successfully tested in the patients after cartilage transplantation, in the brain examination using fMRI, and in the stress evaluation. The method has been applied in patients with MACT (matrix associated chondrocyte transplantation) for better distinguishing between native and transplant cartilage. It is very useful also in post-operative monitoring of such patients.

Image enhancement with orientation to: knee joint, ankle, Achilles tendon, hand, liver and vocal tract was also studied. New sequences for imaging and spectroscopy have been developed. The comparison measurements have been performed at magnetic field strengths 0.18T, 3.0T and 7T and spectroscopic measurements have been performed at 3.0T. The investigation has been performed in estimation of relaxation constants of Achilles tendon. The effect of caffeine and

alcohol has been tested by imaging of vessels dilatation under the influence of the above mentioned substances. The method for diaphragm movement monitoring has been developed, for improving the liver spectroscopy. The fast sequence for imaging the vocal tract has been designed as well. All methods have been tested on volunteers and can be applied in patients at orthopaedic clinics for patients follow-up.

Within a State Program of Research and Development the "**Centre for NMR Based Material Imaging**" was established in the Institute of Measurement Science as a part of the "National centre of NMR" – centre of excellence. Main goals of the centre are: support of research and development projects, support of activities of other research centres, education of experts and PhD students for NMR, function of an initialisation centre for new products and technologies support.

**International aspects of the research** can be documented by the cooperation with MR Centre, Highfield MR, Department of Radiology, Medical University of Vienna, Austria and namely by its incorporation into the ERA within the EU 6th Framework Program "Maria Currie", project PHELINET (Polarised Helium Lung Imaging Network) where the main of the 16 partners were Université Paris-Sud and Université Lyon in France and Università degli studi di Trieste, Italy. The project was aimed at a wide dissemination and a rapid transfer to end-users of the hyperpolarized (HP) Helium3 lung MRI technique. It was focused on realization of this technique for lung diseases diagnostics, for evaluation of therapy efficacy, for the development of improved, efficient and robust methods and tools for HP Helium3 lung MRI. Proposed methodology has significant potential for clinical monitoring and imaging of patients in natural vertical position. The main scientific achievements of this project from the IMS SAS were analysis of RF resonators as measuring sensors, original algorithm of their optimisation using elements from evolutionary strategy and realisation of RF resonators of "phased array" type for parallel imaging and measurement based on MR.

Research in the **Department of Biomeasurements** was oriented to research of new measuring methods for biology and medicine and to development of measuring technologies and devices for their application. The measuring methods were oriented to the human cardiovascular system and were based on mathematical models of the measured object - the heart - with the aim to assess its main parameters that allow using the methods for non-invasive assessment of the heart state and functionality. Corresponding measuring technology and experimental devices have been developed to enable application of the proposed methods in biomedical research and in experimental medical diagnostics and therapy.

Within the assessed period, the activities in the Department were focused on

- investigation of practically usable measuring methods for non-invasive diagnostics of local cardiac pathologies based on simplified models of the cardiac electric generator and solution of the inverse problem of electrocardiology,
- analysis of conditions that influence the results of inverse methods and development of new biosignal processing methods for identification of selected pathological states of the heart,

- development of advanced technologies for biomedical measuring systems oriented to multichannel measurement of the cardiac electrical field and to experimental measurements on isolated animal hearts.

The method for **non-invasive assessment of cardiac ischemia** was extended to identification of two lesions present in case of the two-vessel disease. The method is based on an inverse solution with 2 dipoles and uses changes of time integrals of ECG potentials on the chest surface measured during ischemia manifestation after a stress test. To improve reliability and robustness of the method, several inversely obtained dipole pairs close to the best solution were analysed and criteria for identification of 2 lesions were proposed. Using these criteria, more than 75% of cases with 2 lesions and all cases with single lesion could be identified in a simulation study. The mean localisation error of identified lesions was 1.2 cm; the mean error of the dipole orientation was 20°.

Possible **influence of heart rate variability and individual patient torso geometry** on identification of the ischemic lesions was analysed on simulated as well as real patient data. The changed heart rate and corresponding changes of QT intervals in ECG during the stress test cause errors in computed dipole parameters. Their compensation using the formula of QT interval estimation according to Fridericia was proposed. Testing of this approach in 5 patients showed that the error of the QT estimate did not exceed 5% and errors of estimated lesion positions dropped about 50% of to less than 12 mm. The influence of the patient torso shape and internal organs on the inverse localisation of ischemic lesions was analysed in a simulation study where small lesions were inversely localised using several realistic torso models obtained from MRI. The mean error of the lesion localisation was 1.77 cm if a standard torso model was used and dropped to 1.04 cm if the model was adjusted to approximate the original torso with properly positioned electrodes. Experiments on ECG data from 8 patients with coronary artery disease showed similar results and confirmed that at least a torso model adjusted to the real patient's measures should be used if CT or MRI is not available.

Method for **detection of a delta wave in the ECG signal based on continuous wavelet transform** based on calculation and evaluation of modulus maxima lines (MML) of the wavelet transform was proposed. Theoretical analysis of the problem showed that it is possible to distinguish the changed slope of the ECG curve and simultaneously to determine its location in time. The method was tested on both, simulated and measured ECG signals (3 healthy persons, 7 patients) and it was shown that it is able to correctly detect presence of the delta wave in ECG signals, except few leads with antisymmetric or negative biphasic shape.

Experimental **testing of non-invasive localisation of ischemia** was realized within an international cooperation with a polish partner. ECG signals from patients measured in 64 leads at rest and during the stress were used for the study of heart rhythm changes compensation and for experimental inverse identification of one or two ischemic myocardial lesions. For 8 patients the difference integral maps fulfilled criteria for using the suggested method (suspicion of local ischemia). Comparison of the inverse results with the results of the currently used invasive diagnostic methods - coronarography and SPECT - showed that for 4 patients (2 with two-vessel disease, 2 with one lesion) the localisation of the lesions was in full agreement, results for one patient with two-vessel disease corresponded partially and in

remaining 3 patients one lesion was also correctly assessed but its location was not precise enough what could have been caused by the use of a standard torso model.

Several **biomedical measuring systems** for application of proposed methods were developed. Compact multichannel ECG system ProCardio for non-invasive location of myocardial ischemia with active electrodes and intelligent data acquisition unit enabling measurement of up to 144 ECG leads was developed. Two systems for Faculty of Medicine in Bratislava and Faculty of Biomedical Engineering, CTU in Prague were built. Devices BioLab-F and BioLab-P for measurement of biophysical parameters during pharmacological experiments on isolated animal hearts were developed for pharmacological research at several institutes of SAS and Faculty of Medicine in Bratislava. They use a smart unit measuring electrical outputs of the Langendorff system for "in vitro" heart experiments and built-in analysis of the signal changes induced by applied drugs. For real-time signal processing in the BioLab-P system, parallel software architecture was designed that enables optimal use of the performance of the current multicore computing systems.

The research in the Department of Biomeasurements was organised within two national VEGA project and two APVV projects in cooperation with a number of partners. At the national level the most important partners were the Institute of Normal and Pathological Physiology SAS in Bratislava (modelling of the myocardium excitation), Slovak Healthcare University in Bratislava (experimental verification of proposed methods and medical interpretation of the results) and Faculty of Electrical Engineering and Information Technology (development of measuring technologies for medicine). **International cooperation** of the department include several bilateral international projects with Institute of Technical Physics and Materials Science CRIP HAS in Budapest and University of Veszprem, Hungary (model-based analysis of patients measured in Hungary), Institute for Information Transmission Problems RAS in Moscow, Russia (alternative methods of the inverse solution), Institute of Biocybernetics and Biomedical Engineering PAS in Warszawa, Poland (experimental verification of proposed methods on data measured in Warszawa) and Faculty of Biomedical Engineering, CTU in Prague, Czech Republic (common development of biomedical measuring technologies).

## ii. **Concept of R&D activity of the Organisation for the next four years (max. 5 pages)**

In concordance with the Foundation Charter of the Institute of Measurement Science, the research and development activity of the Institute in next four years (2012-2015) is aimed at

- high-quality basic and applied research focused on advanced measuring methods and methods for mathematical-statistical processing of measured data,
- solution of specific measurement problems in research, industry and society and development of dedicated measuring systems.

This activity will be in accordance with priorities within the European Research Area, namely with those formulated in the EU Framework Programmes and with national scientific priorities expressed recently in the Minerva 2.0 strategy for building knowledge-based economy in Slovak Republic and targets development of advanced methods for non-destructive material testing in scientific and industrial applications, non-invasive

measurements and diagnostics in biomedicine and research of new materials. In particular, the research will be focused on the following areas:

- **measurement science** incorporating research of mathematical, statistical and computational methods, tools and algorithms necessary for the fundamental understanding of the measurement processes and systems, and methods for evaluation of measured data,
- **non-destructive testing and diagnostics in research and industry** using X-ray microtomography, MR tomography, optoelectronic methods, active and passive infrared thermography and magnetometric methods for materials research, biological and paleontological sciences, technical diagnostics and applications for preserving the cultural heritage,
- **non-invasive diagnostic methods for medicine** based on high-resolution and functional MR imaging, magnetometric methods for examination and diagnostics of lungs, liver and brain, methods and devices for measurement, modelling and model-based diagnostics of the electric activity of biological systems (ECG, EGG), including mathematical and statistical methods and algorithms for biomedical applications.
- **research of new materials and technologies for advanced measuring devices**, including SQUID magnetometric methods based on low-temperature superconductors and material research focused on high-temperature superconductors

These areas are continuation and extension of the current research projects and are based on scientific experience of the teams, broad national and international cooperation and on available and expected new infrastructure obtained mainly from ERDF.

#### i. **Present state of knowledge and status of ongoing research related to the subject of the Concept, from both international and national perspective**

Current research in **measurement science** is focused on mathematical models of the measuring objects/systems and on the mathematical and statistical methods for evaluation of the measurement results and expression of their uncertainties. The crucial question is the assurance of traceability of the measurement results by using e.g. calibration methods and/or the interlaboratory comparisons. The significant obstacle for evaluation of uncertainties in more complex models is an insufficient theoretical development for models with systematic effects. Within the recent decade, the research revealed the significance of biologically inspired models for data representation and processing, in particular the Hierarchical Temporal Memory (HTM) Bayesian network models. On the other hand, the analyses of physiological and other real data can benefit from methods developed for the analysis of nonlinear and chaotic behaviour. Future research will be oriented towards novel **linear and nonlinear modelling and prediction methods**, including methods based on nonlinear dynamical systems, biologically inspired hierarchical neuronal network models, advanced methods for analysis of time series and to pattern recognition, and functional data analysis (FDA), mainly the development of a methodology for clustering and prediction of sets of smoothly varying curves. Current research in applied mathematics and measurement science is oriented also towards development of **methods for biomedical research** and its applications, e.g. for cognitive neuroscience where models and methods for monitoring sustained attention, fatigue, sleepiness, or excessive workload are of great interest. The research in the area of probabilistic modelling of the sleep process can help to understand human performance decrements due to sleep disturbance and sleep loss.

**Infrared thermographic methods** belong to the state of art progressive testing methods intensively developed in the last decades. In case of active infrared thermography the

object under test is thermally activated by pulse or periodical source of IR radiation and its temperature is scanned by a thermographic camera. It enables to find defects in materials or large objects such as airplane wings, walls or historical fresco.

Up-to-date tomographic methods include **X-ray computed tomography** (CT), nuclear magnetic resonance tomography (NMR), neutron, optic and ultrasound tomography. Each of has its own advantages and drawbacks and also preferred areas of application. **X-ray microtomography** (microCT) with extremely high resolution down to 500 nm contemporary finds wide field of applications in materials research, electronics, microelectronics, mineralogy, geology, palaeontology, biology and in many others areas.

Current basic research of **MR imaging methods** is oriented on micro- and nano-structure imaging in biological and material research, to investigation of suitable physical methods, new transducers and special sequences for imaging. New applications of MR techniques with potential of use in health service and material research include study of porous media, imaging using ferrofluids as contrast media, non-destructive material defectoscopy, nanolayers detection and imaging, susceptibility measurements and imaging of thin layer biological and non biological materials. Very important are magnetometric methods oriented to weak magnetic materials, imaging of nanoparticles in liquids and gases and non-invasive quantitative imaging of biogenic iron-connected disorders.

Research of **magnetometric methods** is oriented to development of measuring methods and equipment for biological objects as well as for specific materials. Big attention is paid to the study of iron as an age biomarker and with connection of neurodegenerative diseases. In this connection SQUID magnetometric methods with extreme sensitivity represent very promising method complementary with MRI. New applications of SQUID magnetometric methods are magnetically labelled immunoassays for magnetic detection of breast cancer cells or leukemia cells or non-destructive testing of materials and detection of hidden defects by studying the relations between the internal strength, structural changes and magnetic properties.

The use of **model-based approach for non-invasive cardiac diagnostics** now span from heart hypertrophy and ischemia to cardiac arrhythmias. Clinical electrocardiographic (ECG) criteria are empirical and do not provide detailed information on the heart electrophysiology. These facts led to the study of the surface cardioelectric field and its interpretation using properly constructed computer models. Modelling of the electrical activation of the myocardium and computation of body surface potentials help to understand the genesis and characteristics of real signals. Models as a part of the measuring method allow non-invasive estimate of the cardiac activation - cardiac imaging - that helps in correct cardiac diagnostics.

The present state of research of **material research and high-temperature superconductors and selected nanomaterials** is focused on bulk and multifilament superconducting conductors characterised by their use in incoming industrial applications, such as conductors, motors, magnets, energy storage systems, superconducting levitation transportations, bearings, etc. The key task in these applications is to increase the critical current density. During the last years, many of the investigations in the field of mechanochemical synthesis of oxide materials have been performed. These processes lead to the formation of new materials and nanostructures and represent the low-cost strategy for large-scale productivity. Oxides such as  $\text{Al}_2\text{O}_3$ ,  $\text{Mn}_2\text{O}_3$ ,  $\text{TiO}_2$ ,  $\text{SnO}_2$ ,  $\text{VO}_2$ ,  $\text{V}_2\text{O}_3$  represent important smart materials, e.g. in the new Li-ion cells.

## **ii. Organisation's role or significance in the overall research effort within the field of the Concept on both the national and international scales**

As it was shown in the summary of the research activity during the assessment period, the Institute has significantly contributed on the national and international level to the research domains listed in the Concept and these domains are in correspondence with priorities of the European Research Area. The Institute's results contributed to EU FP and COST programmes and are accepted by international scientific and professional societies including IMEKO, IFMBE, IEEE, SPIE, ICE. Number of international projects is running and new projects, including EU FP7 are being prepared. On national level, intensive cooperation traditionally exists with SAS institutes, universities, important industrial partners and cultural and healthcare institutions, including several common laboratories.

During the assessed period the Institute was incorporated as a partner into four consortia projects: Centre of Excellence for New Technologies in Electrical Engineering (CENTE), Centre of Excellence for Research and Development of Composite Construction Materials for Machinery, Building and Medical Applications (CEKOMAT), Centre of Competence for New Materials, Advanced Technologies and Power Engineering and National Centre of NMR. These projects significantly contributed to the improvement of the Institute's infrastructure for non-destructive testing using microCT, MRI, magnetometry and optical spectrometry, for information technologies and for development and production of measuring systems and gave us access to the facilities of other consortia members.

These projects, together with two European Social Fund projects contributed also to education of young scientists in the Institute and to improvement of its personnel structure.

Improved infrastructure and personnel structure has also strengthened the position of the Institute on national and international level as it can facilitate more intensive cooperation with research teams and laboratories in Slovakia and within Europe.

## **iii. Objectives of the Concept**

The main objective of the Concept is to provide high-quality basic and applied research focused at the mentioned areas. This objective is based on the scientific experience of the Institute's research staff and on national and international scientific cooperation. The following goals are primary objectives of the Concept:

- Increase of knowledge in measurement science and publication of achieved results in larger extent in high quality international scientific journals and presentations at international conferences;
- Wider participation of the research teams in the ERA projects, namely EU Framework Programmes, as well as in national, namely APVV projects;
- Continuation of the cooperation with power and machine industry and with research and applied institution in the field of biomedicine;
- Further Improvement of the Institute's research infrastructure;
- Education of young researchers and their inclusion into the research teams;
- Extended popularization of the obtained results and science as a whole.

The following partial goals will be targeted:

- Research of new statistical procedures in linear and nonlinear models, prediction methods based on nonlinear dynamical systems, biologically inspired hierarchical



neuronal network models, advanced mathematical statistics for analysis of time series and to pattern recognition methods, evaluation of uncertainties in measurement models with systematic effects, models and methods for biomedical research.

- Research in the field of X-ray microtomography directed to uncertainty evaluation, minimisation of artefacts and applications in metrology, materials research, microelectronics, mineralogy, geology, palaeontology and biology.
- Research of active and passive infrared thermography aimed at non-destructive testing of subsurface defects and inhomogeneities in materials, based on models of the objects and solving problems of optical semi-transparency and variable emissivity.
- Research of continuous measurement of the tilt of reactor vessels in NPPs focused on evaluation of their long-term stability and uncertainty. New physical principles enabling for faster measurement will be searched.
- Material research oriented to magnetic properties of RE-Ba-Cu-O HTS with defined cation non-stoichiometry. Investigation of the process of coexistence of magnetic and superconducting ordering using bulk and possibly thin-film composition structures. Preparation of nanoparticle precursors applicable in superconductors and preparation of  $\text{Fe}_3\text{O}_4$ ,  $\text{VO}_2$ ,  $\text{Mn}_2\text{O}_3$ ,  $\text{TiO}_2$ ,  $\text{SnO}_2$  nanooxides for applications in biomedicine and industry by sonochemical and microemulsion methods. Their magnetic characterization and analysis using SQUID magnetometers.
- Research in the field of magnetic non-destructive methods of materials testing, e.g. hidden defects and study of the relations among the internal strength, structural changes and magnetic properties;
- Design and optimization of SQUID gradiometric and susceptometric measuring methods and devices for detection and localisation of cancer tissue and for study of processes related to a disturbed iron regulation in cardiovascular and tumour diseases  
Research of tumour diagnostics based on direct measurements of the magnetic moment and susceptibility of the measured samples and models of organs;
- Non-destructive MR diagnostics and macro- and microstructures imaging for material research; imaging using magnetic nano-particles and imaging oriented to weak magnetic materials, research of nanoparticles in liquids and gases;
- Research of MRI methods and specific instrumentation for biomedical research with orientation to diagnostics of human articular cartilage, knee joint and ankle, Achilles tendon, hand, liver, heart and vocal tract, noninvasive quantitative imaging of biogenic iron-connected disorders and functional imaging;
- Research of advanced measuring methods based on realistic modelling the cardiac electrical field, development of measuring devices for their application aimed at non-invasive cardiac imaging of the electrophysiological cardiac characteristics at selected pathologies (hypertrophy, ischemia, arrhythmias).

#### **iv. Proposed strategies and methods to be applied, and time schedule**

Concept of the Institute's research in the 2012-2015 period is oriented to material science, biomedicine, power and machine engineering what is concordant with national scientific priorities (formulated in Minerva 2) as well as the priorities of ERA. This gives good substantiation for maintaining and improving of the scientific position of the Institute in the coming period. To fulfil this strategic goal following strategies will be followed:

- Cooperation of the Institute within current consortia in the field of materials research and NDT technologies formed within the EU Structural Funds projects and State research project and further improving the infrastructure of the Institute;
- Joining the University Research Park for Biomedicine to improve the Institute's infrastructure for the research in biomedicine and to further build up the national and international cooperation in this field;
- Use the new Institute's infrastructure to join more larger national projects (e.g. within the APVV grant agency) with strong partners (SAS institutes, Slovak University of Technology) but namely to join international projects, namely FP7 and COST based on current partners (Technical University Vienna, Medical University Innsbruck, Joint Institute for Nuclear Research in Dubna, Polish Academy of Sciences, Czech Technical University) as well as to build up new cooperation in the field of microCT and optoelectronic methods (Nanoelectronics Research Institute in Tsukuba, Japan);
- Cooperation with industrial partners in power industry based on current relations (Nuclear power plants Jaslovské Bohunice and Mochovce) and partnerships within the "Centre of competence for new materials,..." and building cooperation with machine industry, in the frame of our membership in the Association of Machine Industry in Slovakia;
- Preservation of the structure of the research teams in the Institute organised into five departments and their relative independence enabling to apply for projects on national and international level. Stressing joint effort of departments when applying for larger and international projects. Department staff and economic stimulation dependent on success rate in projects and scientific outputs;
- Continuing narrow cooperation with technical universities (STU in Bratislava, TU Kosice and University of Zilina), organisation of lectures, practices and excursions to bring new PhD students in Measurement Technology. Undertake steps to recruit more students from abroad. Increased efforts to gain support for postdocs (Schwartz Fund from the SAS, APVV projects, Maria Curie training fellowships);
- Scientific seminars, including more events with invited prominent speakers from abroad that could reinforce possibilities to start new cooperation and research projects.

#### **Time schedule of proposed strategies and methods**

Majority of the proposed R&D activities has already started, and is currently supported by either scientific grant agencies or industrial partners. Time schedule of the continuing research activities will be in accordance with accepted project proposals generally planned for three years periods. There are several activities that should be planned exactly:

- 2012 - reconstruction of the Institute's building for the Competence centre
- 2013 - finishing building the infrastructure from ERDF, Measurement 2013 conference
- 2014 - use of the new infrastructure
- 2015 - reaccreditation of the PhD study, Measurement 2015 conference

### III. *Partial indicators of the main activities:*

#### 1. Research output

- i. List of the selected publications documenting the most important results of basic research. Total number of publications in the whole assessed period should not exceed the average number of the research employees 35

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- Acta Physica Polonica A. ISSN 0587-4246, 2008, vol. 113, no. 1, p. 219-222. (0.340 - IF2007).
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- [11] PLESCH, G. - BILLIK, P. – CIGÁŇ, Alexander – MAŇKA, Ján. YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7</sub> melt textured thick films grown by infiltration process on YSZ substrate prepared by sol-gel method. In Journal of Alloys and Compounds. ISSN 0925-8388, 2008, vol. 461, p. 61–65. (1.455 - IF2007).
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**ii. List of the selected publications documenting the most important results of applied research**

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#### **iv. List of monographs/books published in Slovakia**

- [1] RUBLÍK, František. *Neparametrické metody*. Bratislava: Vydavateľstvo VEDA, 2011. 709 s. ISBN 978-80-224-1187-5.

#### **v. List of other scientific outputs specifically important for the Organisation (normalization, standardization, maps, etc.)**

In accordance with the Foundation Charter of the Institute, its mission includes design of dedicated measuring methods and systems for non-standard measurement problems in the research. Following outputs of this type were accomplished:

- [1] For the Institute of Experimental Pharmacology SAS in Bratislava a method for evaluation of ECG signals from isolated animal hearts was developed. It enables automated beat detection with identification of normal beats and extrasystoles. New pressure sensors (APT 300 Pressure Transducer and HSE Pressure Coupler) were connected to the system. Corresponding hardware and software was implemented in the previously supplied BioLab-F measuring device in 2008.
- [2] For ExpresTech s.r.o., Bratislava three biomedical measuring devices for measurement and evaluation of biophysical signals enabling assessment of the functional state of the thyroid gland (BioLab-ATR and BioLab-KVS) and 32-channel measurement of ECG signals (ProBio) were built in 2008. The systems were used for education of biomedical engineering students at STU in Bratislava.
- [3] For the Institute of Pathological Physiology, School of Medicine, Comenius University in Bratislava experimental "Digital comparator of arterial pressures" for measurement

of pressures and identification of pressure wave parameters in the human vascular system was developed and built in 2009.

- [4] For Faculty of Biomedical Engineering, Czech Technical University in Prague, and Faculty of Medicine, Comenius University in Bratislava two compact 64-channel ECG measuring systems ProCardio for non-invasive location of myocardial ischemia were developed and realised in 2009 and 2010.
- [5] For the Joint Institute for Nuclear Research in Dubna, Russia the Institute contributed to a new method of distributed control of generation of intense beams of heavy ions and polarised nuclei aimed at searching mixed phases of the matter and investigation of polarising effects during collisions of ions with energy up to 11 GeV. Moreover, a new method and electronics controlling the magnetic field in the Nuclotron accelerator was developed and built in 2010.
- [6] For the Institute of Experimental Pharmacology SAS in Bratislava new method for evaluation of biosignals from the Langendorff experiments on isolated animal hearts was developed. It enables automated identification of waves, slopes and ventricular pressures. Corresponding software was implemented in the previously supplied BioLab-F measuring device in 2010.
- [7] For the Institute of Normal and Pathological Physiology SAS measuring device BioLab-P (based on Data Translation DT9812-10V module) for measurement and evaluation of biosignals from the experiments on animal hearts was designed in 2011. The device will be used to process signals from the sensors available in the partner institute.

#### **vi. Table of research outputs**

*Table **Research outputs** shows research outputs in number of specified entries; these entries are then divided by FTE employees with a university degree (from Tab. Research staff) for all Organisation at the respective year; finally these entries are divided by the total salary budget (from Tab. Salary budget).*

*(and the name of research organisations appears in the list of author)*

Research outputs	2007			2008			2009			2010			2011			total			
	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	averaged number per year	av. No. / FTE	av. No. / salary budget
chapters in monographs, books published abroad	0	0,000	0,00	1	0,027	1,75	5	0,134	8,45	4	0,109	6,55	6	0,186	10,34	16	3,2	0,091	5,52
chapters in monographs, books published in Slovakia	1	0,031	1,85	1	0,027	1,75	0	0,000	0,00	0	0,000	0,00	0	0,000	0,00	2	0,4	0,011	0,69
CC publications	13	0,400	23,99	19	0,508	33,22	12	0,322	20,27	15	0,407	24,55	15	0,466	25,86	74	14,8	0,420	25,54
scientific publications indexed by other databases (specify)	12	0,369	22,14	15	0,401	26,22	15	0,403	25,34	10	0,272	16,37	8	0,248	13,79	60	12,0	0,341	20,71
scientific publications in other journals	8	0,246	14,76	8	0,214	13,99	4	0,107	6,76	12	0,326	19,64	9	0,279	15,52	41	8,2	0,233	14,15
publications in proc. of international scientific conferences	34	1,046	62,73	17	0,455	29,72	48	1,288	81,08	6	0,163	9,82	47	1,459	81,03	152	30,4	0,863	52,47
publications in proc. of nat. scientific conferences	3	0,092	5,54	6	0,160	10,49	1	0,027	1,69	4	0,109	6,55	15	0,466	25,86	29	5,8	0,165	10,01
active participations at international conferences	54	1,662	99,63	39	1,043	68,18	43	1,154	72,64	34	0,923	55,65	58	1,801	100,00	228	45,6	1,294	78,70
active participations at national conferences	11	0,338	20,30	21	0,561	36,71	5	0,134	8,45	8	0,217	13,09	21	0,652	36,21	66	13,2	0,375	22,78

Other databases: WOS, Scopus, IOP, INSPEC, ISI Proceedings, Index Copernicus International, Mathematical Reviews, Zentralblatt MATH.

#### vii. List of registered patents

- [1] Hain, Miroslav - Bartl, Ján - Kúr, J. - Kúr, B. *The way of surface defects seeking, especially of bearings and the device for performing this way* (Spôsob vyhládavania povrchových defektov, najmä ložiskových krúžkov a zariadenie na vykonávanie tohto spôsobu). Patent no. SK 285659 B6. Date of entry into effect of the patent: 3.5.2007. Owner: Institute of Measurement Science SAS, Bratislava, SK; Mesing, s. r. o., Brno, CZ.
- [2] Andris, Peter - Frollo, Ivan. *The way of phase measurement in NMR tomography* (Spôsob merania fázy v NMR tomografii). Patent no. SK 286298 B6. Date of entry into effect of the patent: 7.7.2008. Owner: Institute of Measurement Science SAS.

- [3] Rosík, Vladimír – Smrčka, P. – Tyšler, Milan – Hána, K. - Kneppo, P. - Karas, Slavomír – Mužík, J. *System for polygraphic scanning and evaluating of biological signals in real time* (Systém pro polygrafická snímání a vyhodnocování biologických signálů v reálném case). Industrial design no. CZ 20781 U1. Entered: 19.04.2010. Owner: Faculty of Biomedical Engineering CTU in Prague, Kladno, CR; Institute of Measurement Science SAS, SR
- [4] Rosík, Vladimír - Kulišov, Andrej - Tyšler, Milan - Hána, K. - Kneppo, P. *Active electrode for measuring of bioelectric signals* (Aktivní elektroda pro snímání bioelektrických signal). Industrial design no. CZ 20692 U1. Entered: 29.03.2010. Owner: Faculty of Biomedical Engineering CTU in Prague, Kladno, CR; Institute of Measurement Science SAS, SR.
- [5] Kneppo, P. – Tyšler, Milan – Hána, K. – Rosík, Vladimír – Smrčka, P. – Karas, Slavomír – Mužík, J. *System for polygraphic scanning and evaluating of biological signals in real time* (Systém na polygrafické snímanie a vyhodnocovanie biologických signálov v reálnom čase). Industrial design no. SK 5565 Y1. Date of entry into effect of the industrial design: 30.8.2010. Owner: Faculty of Biomedical Engineering CTU in Prague, Kladno, CR; Institute of Measurement Science SAS, SR.
- [6] Rosík, Vladimír - Kulišov, Andrej - Tyšler, Milan - Hána, K. - Kneppo, P. *Active electrode for measuring of bioelectric signals* (Aktívna elektróda na snímanie bioelektrických signálov). Industrial design no. SK 5598 Y1. Date of entry into effect of the industrial design: 30.9.2010. Owner: Faculty of Biomedical Engineering CTU in Prague, Kladno, CR; Institute of Measurement Science SAS, SR.
- [7] Ondriš, Ľubomír – Buzási, Ján – Rusina, Viktor – Ondrejkoč, Peter – Trutz, Marián *Optoelectronic hydro-levelling sensor with refracted light bundle* (Optoelektronický hydronivelačný snímač s lomeným svetelným zväzkom). Patent no. SK 287855 B6. Date of entry into effect of the patent: 4.1.2012. Owner: Institute of Measurement Science SAS, SR
- [8] Rusina, Viktor - Ondriš, Ľubomír - Ondrejkoč, Peter – Trutz, Marián. *The way of gas pressure measurement and the scheme of its realization* (Spôsob merania tlaku plynov a zapojenie na jeho realizáciu). Patent no. SK 287861 B6. Date of entry into effect of the patent: 4.1.2012. Owner: Institute of Measurement Science SAS

#### **viii. Supplementary information and/or comments on the scientific output of the Organisation**

The numbers of publications shown in the table “Research outputs” are in the same structure as in the annual reports, i.e. possible supplementary publications included in next year annual report were also counted in the next year. List of publication that did not appear



in annual reports is shown in the document "Publications – Supplement" at our web page <http://www.um.sav.sk/en/publications-and-citations/>.

## 2. Responses to the scientific output

Table **Citations** shows specified responses to the scientific outputs; these entries are then divided by the FTE employees with a university degree (from Tab. Research staff) for all Organisation at the respective year; finally these entries are divided by the total salary budget (from Tab. Salary budget).

Citations	2006			2007			2008			2009			2010			total			
	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	averaged number per year	av. No. / FTE	av. No. / salary budget
Web of Science	114	3,5	210,3	130	3,5	227,3	138	3,7	233,1	172	4,7	281,5	188	5,8	324,1	742	148,4	4,2	256,1
(specify Database 1)	21	0,6	38,7	30	0,8	52,4	35	0,9	59,1	52	1,4	85,1	46	1,4	79,3	184	36,8	1,0	63,5
(specify Database 1)	0	0,0	0,0	0	0,0	0,0	0	0,0	0,0	0	0,0	0,0	0	0,0	0,0	0	0,0	0,0	0,0
in monographs, conf. proceedings and other publications abroad	4	0,1	7,4	14	0,4	24,5	6	0,2	10,1	6	0,2	9,8	6	0,2	10,3	36	7,2	0,2	12,4
in monographs, conf. proceedings and other publications in Slovakia	0	0,0	0,0	9	0,2	15,7	6	0,2	10,1	1	0,0	1,6	0	0,0	0,0	16	3,2	0,1	5,5

### i. List of 10 top-cited publications from staff members since the establishment of the Organisation up to 2010 and number of their citations in the period 2006 - 2010

- [1] ROSIPAL, Roman - TREJO, L.J. Kernel partial least squares regression in RKHS. In Journal of Machine Learning Research, 2001, vol. 2, p. 97-123. ISSN 1532-4435.  
 Number of citations in 2006-2010: **126** (100 WOS + 26 SCOPUS)  
 Total number of citations: **126** (100 WOS + 26 SCOPUS)

- [2] STADNIK, T.W. – CHASKIS, C. – MICHOTTE, A. – SHABANA, W.M. – VAN ROMPAEY, K. – LUYPAERT, R. – BUDINSKÝ, Ľuboš. – JELLÚŠ, Vladimír. – OSTEAX, M. Diffusion-weighted MR imaging of intracerebral masses: comparison with conventional MR imaging and histologic findings. In American Journal of Neuroradiology, 2001, Vol. 22, no. 5, p. 969-976. ISSN 0195-6108.  
Number of citations in 2006-2010: **89** (69 WOS + 20 SCOPUS);  
Total number of citations: **164** (135 WOS +29 SCOPUS)
- [3] MATEJ, Samuel. – LEWITT, R.M. Practical considerations for 3-D image reconstruction using spherically symmetric volume elements. In IEEE Transactions on Medical Imaging. Vol. 15, no. 1, 1996, p. 68-78. ISSN 0278-0062.  
Number of citations in 2006-2010: **55** (36 WOS + 19 SCOPUS)  
Total number of citations: **85** (61 WOS + 24 SCOPUS)
- [4] TEPLAN, Michal. Fundamentals of EEG measurement. In Measurement Science Review, 2002, vol. 2, p. 1-11. ISSN 1335-8871.  
Number of citations in 2006-2010: **52** (23 WOS + 29 SCOPUS)  
Total number of citations: **57** (30 WOS+27 SCOPUS)
- [5] LI, P. - FARKAŠ, Igor - MACWHINNEY, B. Early lexical development in a self-organizing neural network. In Neural Networks, 2004, vol. 17, p. 1345-1362. ISSN 0893-6080.  
Number of citations in 2006-2010: **42** (40 WOS + 2 SCOPUS)  
Total number of citations: **42** (40 WOS + 2 SCOPUS)
- [6] ROSIPAL, Roman. Kernel partial least squares for nonlinear regression and discrimination. In Neural Network World : International Journal on Non-Standard Computing and Artificial Intelligence, 2003, vol. 13, no. 3, p. 291-300. ISSN 1210-0552.  
Number of citations in 2006-2010: **23** (21 WOS + 2 SCOPUS)  
Total number of citations: **23** (21 WOS + 2 SCOPUS)
- [7] WITKOVSKÝ, Viktor. Computing the distribution of a linear combination of inverted gamma variables. In Kybernetika, 2001, vol. 37, no. 1, p. 79-90. ISSN 0023-5954.  
Number of citations in 2006-2010: **17** (16 WOS + 1 SCOPUS)  
Total number of citations: **23** (21 WOS+2 SCOPUS)
- [8] MLYNÁRIK, V. - SZOMOLÁNYI, Pavol - TOFFANIN, R. - VITTUR, F. - TRATTNIG, Siegfried. Transverse relaxation mechanisms in articular cartilage. In Journal of Magnetic Resonance, 2004, vol. 169, p. 300-307. ISSN 1090-7807.  
Number of citations in 2006-2010: **22** (21 WOS + 1 SCOPUS)  
Total number of citations: **22** (21 WOS + 1 SCOPUS)

- [9] TRATTNIG, S. - MAMISCH, T.C. - WELSCH, G.H. - GLASER, C. - SZOMOLÁNYI, Pavoľ - GEBETSROITHER, S. - STASTNY, O. - HORGER, W. - MILLINGTON, S. - MARLOVITS, S. Quantitative T2 mapping of matrix-associated autologous, chondrocyte transplantation at 3 Tesla. In Investigative Radiology, 2007, vol. 42, no. 6, p. 442-448. ISSN 0020-9996.  
Number of citations in 2006-2010: **15** (15 WOS)  
Total number of citations: **15** (15 WOS)
- [10] ROSIPAL, Roman - KOSKA, Miloš - FARKAŠ, Igor. Prediction of chaotic time-series with a resource-allocating RBF network. In Neural Processing Letters, 1998, vol. 7, no. 3, p. 185-197. ISSN 1370-4621.  
Number of citations in 2006-2010: **7** (6 WOS + 1 SCOPUS)  
Total number of citations: **13** (12 WOS+1 SCOPUS)

**ii. List of 10 top-cited publications from staff members published 2000 - 2010 and number of their citations in the period 2006 - 2010**

- [1] ROSIPAL, Roman - TREJO, L.J. Kernel partial least squares regression in RKHS. In Journal of Machine Learning Research, 2001, vol. 2, p. 97-123. ISSN 1532-4435.  
Number of citations in 2006-2010: **126** (100 WOS + 26 SCOPUS)  
Total number of citations: **126** (100 WOS + 26 SCOPUS)
- [2] STADNIK, T.W. – CHASKIS, C. – MICHOTTE, A. – SHABANA, W.M. – VAN ROMPAEY, K. – LUYPAERT, R. – BUDINSKÝ, Ľuboš. – JELLÚŠ, Vladimír. – OSTEAX, M. Diffusion-weighted MR imaging of intracerebral masses: comparison with conventional MR imaging and histologic findings. In American Journal of Neuroradiology, 2001, Vol. 22, no. 5, p. 969-976. ISSN 0195-6108.  
Number of citations in 2006-2010: **89** (69 WOS + 20 SCOPUS)  
Total number of citations: **164** (135 WOS +29 SCOPUS)
- [3] TEPLAN, Michal. Fundamentals of EEG measurement. In Measurement Science Review, 2002, vol. 2, p. 1-11. ISSN 1335-8871.  
Number of citations in 2006-2010: **52** (23 WOS + 29 SCOPUS)  
Total number of citations: **57** (30 WOS+27 SCOPUS)
- [4] LI, P. - FARKAŠ, Igor - MACWHINNEY, B. Early lexical development in a self-organizing neural network. In Neural Networks, 2004, vol. 17, p. 1345-1362. ISSN 0893-6080.  
Number of citations in 2006-2010: **42** (40 WOS + 2 SCOPUS)  
Total number of citations: **42** (40 WOS + 2 SCOPUS)

- [5] ROSIPAL, Roman - TREJO, L. J. - MATTHEWS, B. Kernel PLS-SVC for linear and nonlinear classification. In Twentieth International Conference on Machine Learning. Editor T. Fawcett, N. Mishra. - 2003, p. 640-647. ISBN 0-1-57735-189-4.  
Number of citations in 2006-2010: **26** (19 WOS + 7 SCOPUS)  
Total number of citations: **28** (21 WOS+7 SCOPUS)
- [6] ROSIPAL, Roman. Kernel partial least squares for nonlinear regression and discrimination. In Neural Network World : International Journal on Non-Standard Computing and Artificial Intelligence, 2003, vol. 13, no. 3, p. 291-300. ISSN 1210-0552.  
Number of citations in 2006-2010: **23** (21 WOS + 2 SCOPUS)  
Total number of citations: **23** (21 WOS + 2 SCOPUS)
- [7] WITKOVSKÝ, Viktor. Computing the distribution of a linear combination of inverted gamma variables. In Kybernetika, 2001, vol. 37, no. 1, p. 79-90. ISSN 0023-5954.  
Number of citations in 2006-2010: **17** (16 WOS + 1 SCOPUS)  
Total number of citations: **23** (21 WOS+2 SCOPUS)
- [8] MLYNÁRIK, V. - SZOMOLÁNYI, Pavol - TOFFANIN, R. - VITTUR, F. - TRATTNIG, Siegfried. Transverse relaxation mechanisms in articular cartilage. In Journal of Magnetic Resonance, 2004, vol. 169, p. 300-307. ISSN 1090-7807.  
Number of citations in 2006-2010: **22** (21 WOS + 1 SCOPUS)  
Total number of citations: **22** (21 WOS + 1 SCOPUS)
- [9] TEPLAN, Michal - KRAKOVSKÁ, Anna - ŠTOLC, Svorad. EEG responses to long-term audio-visual stimulation. In International Journal of Psychophysiology, 2006, vol. 59, p. 81-90. ISSN 0167-8760.  
Number of citations in 2006-2010: **12** (7 WOS + 2 SCOPUS + 3 other)  
Total number of citations: **12** (7 WOS + 2 SCOPUS + 3 other)
- [10] KUSHCH, I. - ARENDAČKÁ, Barbora - ŠTOLC, Svorad - MOCHALSKI, P. - FILIPIAK, W. - SCHWARZ, K. - SCHWENTNER, L. - SCHMID, A. - DZIEN, A. - LECHLEITNER, M. - WITKOVSKÝ, Viktor - MIEKISCH, W. - SCHUBERT, J. - UNTERKOFLE, K. - AMANN, A. Breath isoprene - aspects of normal physiology related to age, gender and cholesterol profile as determined in a proton transfer reaction mass spectrometry study. In Clinical Chemistry and Laboratory Medicine, 2008, vol. 46, no. 7, p. 1011-1018. ISSN 1434-6621.  
Number of citations in 2006-2010: **8** (6 WOS + 2 SCOPUS)  
Total number of citations: **8** (6 WOS + 2 SCOPUS)

**iii. List of top-cited authors from the Organisation (at most 10 % of the research employees) and their number of citations in the period 2006 - 2010**

- [1] Roman Rosipal  
 Number of citations in 2006-2010: **199** (161 WOS + 38 SCOPUS)  
 Total number of citations: **229** (190 WOS+39 SCOPUS)
- [2] Pavol Szomolányi  
 Number of citations in 2006-2010: **112** (105 WOS+ 7 SCOPUS)  
 Total number of citations: **121** (114 WOS+7 SCOPUS)
- [3] Viktor Witkovský  
 Number of citations in 2006-2010: **65** (51 WOS + 7 SCOPUS + 7 other)  
 Total number of citations: **118** (61 WOS+9 SCOPUS+48 OTHER)
- [4] Michal Teplan  
 Number of citations in 2006-2010: **75** (38 WOS + 28 SCOPUS + 9 OTHER)  
 Total number of citations: **86** (41 WOS+30 SCOPUS + 15 OTHER)

#### **iv. Supplementary information and/or comments on responses to the scientific output of the Organisation**

The number of citations presented in the table "Citations" was calculated as a sum of citations stated in the annual report of the next year plus supplements from the annual reports stated in following years plus possible newly found citations that were not shown in last four annual reports. Detailed list of citations is available at the web page <http://www.um.sav.sk/en/publications-and-citations>.

### **3. Research status of the Organisation in the international and national context**

- **International/European position of the Organisation**
    - i. **List of the most important research activities documenting international importance of the research performed by the Organisation, incl. major projects (details of projects should be supplied under Indicator 4). Provide the arguments why the selected projects are particularly important and represent the international position of the Organisation ).**
- [1] 6<sup>th</sup> FP, STREP project "Breath-gas analysis for molecular-oriented detection of minimal diseases" (BAMOD). This project was focused on the diagnosis of minimal disease and early stages of lung and oesophageal cancer. The analytical techniques have been gas chromatography with mass spectrometric detection (GC-MS), proton transfer reaction mass spectrometry (PTR-MS), selected ion flow tube mass spectrometry (SIFT-MS), laser spectrometry and ion mobility spectrometry (IMS). The

project consortium consisted from 13 EU partners, including IMS SAS who was responsible, as a WP leader, for development of statistical algorithms for data analysis of breath gas concentration measurements.

- [2] 6<sup>th</sup> FP, Maria Currie project “Polarized Helium Lung Imaging Network” (PHELINET)- The project was created for a wide dissemination and a rapid transfer to end-users of the hyperpolarized (HP) Helium3 lung MRI technique, through pan-European training and intense cooperation of eleven academic and six industrial collaborators. It focuses on (i) the realization of the strong potential of this technique for lung diseases diagnostic and for the evaluation of therapy efficacy, (ii) the development and the finalization of improved, efficient and robust methods and tools for HP Helium3 lung MRI.
- [3] Development of the accelerator facility NUCLOTRON, Russia (several projects)- Development of the JINR basic facility Nuclotron for generation of intense heavy ion and polarized nuclear beams allow to use it for new fundamental research in region of the relativistic nuclear physics.
- [4] Diagnostics of human articular cartilage using MRI- Scientific cooperation with Medical University of Vienna- The project is oriented to the diagnostics of human articular cartilage using MRI and imaging of micro- and nanostructures based on magnetic resonance for biomedical and material research. Important factor is mutual visits of scientists and PhD students enabling them to perform imaging experiments on MRI instruments in the laboratories of partners equipped with the world top imaging instrumentation.
- [5] Scientific cooperation with National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan- The aim of the collaboration is the development of advanced optical measurement methods for nanoelectronics. The importance of cooperation is in addition to the scientific plane also in the creation of links between our institute and the important global institution that has long-term cooperation with major Japanese electronics manufacturers and opens up the possibilities for further application of our results in practice.
- [6] Scientific cooperation with the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig, Germany, partly supported by the Alexander von Humboldt Foundation. The common research was focused on development new methods in two dimensional microstructures metrology to estimate the measurement uncertainty of the object position measured by the length photoelectric comparator.
- [7] Agreement on Scientific Cooperation with Department of Inorganic and Physical Chemistry, University of Ghent. Belgium since November 1999 till now.

Together we have prepared new types of superconductors with high critical temperature and current density. Common results were presented on the EUCAS 2007 conference and published.

- [8] Scientific cooperation with the Institute of Biocybernetics and Biomedical Engineering, Polish Academy of Sciences, Warszawa. Research focused on experimental verification of non-invasive localization of ischemic lesions in the Polish-Slovak MAD project "High Resolution Measurement and Model Based Analysis of Cardiac Electric Field".
- [9] Scientific cooperation with CRIP Research Institute for Technical Physics and Material Science, Budapest. Research of multichannel ECG recordings measured in healthy volunteers and patients suffering from angina pectoris.
- [10] Scientific cooperation with the Institute of Computer Science, Academy of Sciences of the Czech Republic in Prague. The joint research project focused on modern methods of processing of electrophysiological signals and study of the phase synchronization and coherence of the EEG.
- [11] Scientific cooperation with the Faculty of Biomedical Engineering CVUT in Prague, Kladno, Czech Republic. Development EuroBio mapping system with the possibility of model-based detection of local ischemia during exercise ECG test.
- [12] Scientific cooperation with Brath Research Institute, Austrian Academy of Sciences, Dornbirn and Innsbruck Medical University, Innsbruck, Austria. Cooperation within the bilateral project APVV SK-AT. Development of new methods and algorithms for statistical data analysis of exhaled breath.
- [13] Scientific cooperation with the Institute for Problems of Information Transmission, Russian Academy of Sciences, Moscow, Russia. Research on noninvasive measurement and information analysis of bioelectrical signals.

## **ii. List of international conferences (co-) organised by the Organisation**

- [1] MEASUREMENT 2007: 6<sup>th</sup> international conference on measurement. Smolenice, Slovak Republic, May 20-24, 2007
- [2] MEASUREMENT 2009: 7<sup>th</sup> international conference on measurement. Smolenice, Slovak Republic, May 19-23, 2009
- [3] MEASUREMENT 2011: 8<sup>th</sup> international conference on measurement. Smolenice, Slovak Republic, April 27-30, 2011
- [4] PROBASTAT 2011: the sixth international conference on probability and mathematical statistics. Smolenice Castle, Slovak Republic, July 4-8, 2011.

- [5] ISABEL 2009: Second international symposium on applied research in biomedicine and communication technologies. Falkensteiner hotel in Bratislava, Slovak Republic, November 11 - 27, 2009.
- [6] Trends in Biomedical Engineering 2009: Eight annual czech- slovak conference with international attendance, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology in Bratislava, Slovak Republic, September 16 - 18, 2009
- [7] International Workshop on Matrices and Statistics 2009: the next in a long-running series of Workshops with the purpose of stimulating exchanges of ideas and research at the interfaces of matrix theory, statistics, and stochastic processes, Smolenice Castle, Slovak Republic, June 23-27, 2009.
- [8] Annual Meeting PHeLInet 2009: International meeting to the project of the 6th FP of the EU, Smolenice Castle, Slovak Republic, March 25 - 28, 2009.
- [9] Winter Workshop on Mathematical Statistics 2008: The format of the workshop is intended to be highly informal, focusing on general and maybe also provoking ideas in mathematical statistics. Bratislava, Slovak Republic, December 15- 16, 2008.
- [10] ROBUST 2008: conference that is devoted to selected trends of mathematical statistics and probability theory, Hotel Mier in Pribylina, Slovak Republic, September 8- 12, 2008.
- [11] Meditech 2008: Dissemination conference of an European Social Fund project MEDITECH - Innovative Program of Modern Biomedical Technologies, Faculty of Chemical and Food Technology, Slovak University of Technology in Bratislava, Slovak Republic, May 26, 2008

### **iii. List of international journals edited/published by the Organisation**

- [1] MEASUREMENT SCIENCE REVIEW, Journal of the Institute of Measurement Science, Slovak Academy of Sciences, Supported by Slovak National Committee MEKO. Bratislava, ISSN 1335-8871, <http://www.measurement.sk>. Central European Science Publisher: Versita Open, Versita Ltd. London, Great Britain, <http://versita.com/msr/> and <http://versitaopen.com>.  
Journal is indexed in: Thomson Reuters Master Journal List, ISI Web of Knowledge, Index Copernicus International, Scopus, Electronic Journals Library, Electronic Journals Index, The Summon, ProQuest, MetaPress, EBSCO Publishing, and more.  
(0,400- IF2010)



**iv. List of edited proceedings from international scientific conferences and other proceedings**

- [1] MEASUREMENT 2007 : 6th International Conference on Measurement. Editors I. Frollo, J. Maňka, V. Juráš. Bratislava, Slovakia: Institute of Measurement Science, SAS, 2007. xiv, 451 s. ISBN 80-969672-0-9.
- [2] PROBASTAT '06 : The Fifth International Conference on Probability and Mathematical Statistics. Editors A. Pázman, J. Volaufová, V. Witkovský. Tatra Mountains Mathematical Publications, Vol. 39. Bratislava : Mathematical Institute, SAS, 2008. 282 s. ISSN 1210-3195.
- [3] MEDITECH : Inovative Program of Modern Biomedical Technologies. Proceedings of the ESF Project Conference with International Participation. Editors J. Labuda, F. Lehocki, M. Tyšler. Bratislava : Slovak University of Technology, 2008, 173 s. ISBN 978-80-227-2881-2.
- [4] MEASUREMENT 2009 : 7th International Conference on Measurement. Editors I. Frollo, J. Maňka, V. Juráš. Bratislava : Institute of Measurement Science, SAS, 2009, 443 s. ISBN 978-80-969672-1-6.
- [5] PROBASTAT 2011 : The Sixth International Conference on Mathematical Statistics (honoring the 80th birthday of Professor Lubomír Kubáček). Editors R. Harman, J. Somorčík, V. Vitkovský. Bratislava : Institute of Measurement Science, SAS, 2011, 46 s.
- [6] MEASUREMENT 2011 : 8th International Conference on Measurement. Editors J. Maňka, V. Witkovský, M. Tyšler, I. Frollo. Bratislava : Institute of Measurement Science, SAS, 2011, 414 s. ISBN 978-80-969-672-4-7.

- **National position of the Organisation**

- i. **List of selected most important national projects (provide the arguments why the selected projects are particularly important and represent the international position of the Organisation)**

- [1] 2003SP200280203 Building of a top laboratory aimed at NMR, State program of research and development- The aim of the project is having built the Centre for NMR Based Material Imaging in the Institute of Measurement Science as a part of the National centre of NMR – centre of excellence. Main goals: education of experts for NMR based measuring systems, technical as well as postdoctoral-study-based scientific, function of an initialization centre for new products and technologies support, support of research and development projects solving, support of activities of other research centres and projects (centres of excellence,...).

Researchers of the Institute participated in research and development projects supported by the Slovak Research and Development Agency (APVV). The projects have been aimed at solving the problems of basic research as well as the applied research in cooperation with SMEs. The Institute have been successful also in the APVV projects aimed at supporting international scientific cooperation in the frame of EU Framework Programme, bilateral international co-operation as well as the projects within the program "Promotion of human potential in research and development and popularization of science".

[2] APVV-51-059005 Application of magnetic and electric measuring methods in non-invasive examination of liver and heart. A SQUID-biosusceptometer has been realized and a noninvasive method of the iron (Fe) content measurement in the liver has been examined. The measuring method has been proved on models and experimentally tested on four patients. Within Slovakia this type of biomagnetic measurements can be performed only at the IMS SAS.

Compact portable system for body surface potential mapping was developed that enables early noninvasive detection of possible myocardial ischemia. On a group of patients after cardiac intervention the ability of the method to identify the reperfused myocardial area was demonstrated, on another group of ischemic patients the possibility to detect an ischemic lesion was tested. Two systems for the Slovak Healthcare University and Faculty of Biomedical Engineering CTU in Kladno were realized.

[3] APVV- RPEU- 008-06 Statistical methods and algorithms for exhaled breath analysis. The project was oriented towards those areas of mathematical statistics that can be useful for development of new effective algorithms for analysis of data obtained in clinical studies planned during the EU FP6 project BAMOD. New results have been achieved in development of methods and algorithms for estimation and testing hypotheses about parameters in mixed linear and nonlinear models, discrimination analysis, nonparametric methods. The project helped to strengthen international cooperation, in particular with the Medical University Innsbruck, Austria. The project enabled active participation of the PhD students and engaged them into research at top international level.

[4] APVV VMSP-P-0052-07/Nanobiosen Electro-chemical biosensors based on nanobiocomposites for quick and efficient analysis of technology-important and health-important components of food and beverages

[5] APVV VMSP-P-0073-09/BioSenSys Pocket analytical device for easy and quick analysis in the field of food industry and diagnostics, based on the single-shot biosensors with the use of nanotechnology

The projects APVV VMSP-P-0052-07 and VMSP-P-0073-09 solved actual problems of the modern society. Measurement of selected beverages and food by means of modern techniques, by using nanobiocomposite based electrodes. Output of these projects has a form of prototypes in two different forms: laboratory and pocket sized devices. Above mentioned projects merged technology of the measurement of physical entities, which has long tradition in the Institute of Measurement Science, with the innovative approaches from the field of biochemistry applied to the food industry. Importance of these projects is emphasized by the fact, that measurement of quality of vines and food is global problem and has potential to enhance life quality of significant portion of population in developed as well as developing countries all around the world.

- [6] APVV LPP-0388-09 Confidence regions for variance components. The project aimed to support postdoctoral position of Mgr. B. Arendacká, PhD. during the period 09/2009 - 08/2012. New results have been obtained in the construction of confidence intervals for variance components in the mixed linear model with two variance components. The project enabled the students' participation in international scientific conferences as well as study stay and cooperation with the National Institute of Standards and Technology, Statistical Engineering Division (SED), Gaithersburg, USA.
- [7] APVV-0513-10 Measuring, communication and information systems for monitoring the cardio-vascular risk in hypertension patients
- [8] APVV-0096-10 Statistical methods for uncertainty analysis in metrology. The project is oriented on statistical methods for metrology, focusing primarily on new methods, models and algorithmic solutions for analysis and evaluation of calibration and interlaboratory comparisons. The project will strengthen the cooperation of the relevant Slovak organizations focused on metrology and methods for proper evaluation of measurement results.
- [9] ESF 13120200032 (Education of PhD students and technical workers for research, development, innovation, and application in measurement science)- Education of PhD students and technical workers for research, development, innovation, and application in measurement science under the guide of top specialist in authorized scientific disciplines. Guarantee of a high quality of the PhD and university study in scientific disciplines: measurement science, metrology and bionics and biomechanics.
- [10] ESF 13120200086 MediTech - innovation program for modern biomedical technologies

The Institute participated, as a partner institution, in several projects supported by the European Regional Development Fund. Those projects supported education of PhD students in the field of Bionics and Biomechanics as well as in Measurement Science and significantly helped to improve the scientific infrastructure of the Institute.

[11] ITMS-26240120015 Creation of CE for research and development of construction composite materials for mechanical and civil engineering and medical applications

[12] ITMS – 26240120011 Centre of Excellence for New Technologies in Electrical Engineering. The Centre was established with the support of the European Regional Development Fund. It was one of the early projects which started closer cooperation among the SAS institutes as well as with Slovak University of Technology. Within this project the computer network of the IMS SAS has been improved.

IMS SAS is a partner in this project.

[13] ITMS – 26240120020 Creation of CE for research and development of construction composite materials for mechanical

[14] ITMS – 26240120019 Centre of Excellence for New Technologies in Electrical Engineering II. The main profit of this project for the IMS SAS was a significant improvement of the infrastructure, we have obtained an advanced device – SQUID magnetometer/susceptometer MPMS-XL7-AC by Quantum Design which belongs to the family of the highest sensitive systems for magnetic measurements.

IMS SAS is a partner in this project.

[15] ITMS- 26240220073 Centre of Competency for New Materials, Advanced Technologies and Power Engineering. This is a biggest project from EU Structural Funds projects where the IMS SAS is participating. It supports cooperation among institutions from Slovak Academy of Sciences, Slovak University of Technology and 9 industrial companies – 15 partners in total. This project enables to cooperate in the field of applied research, enables to improve the scientific equipment and also to make the reconstruction of the buildings intended for research.

IMS SAS is a partner in this project.

Researchers of the Institute have participated in many scientific projects supported by the Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Sciences. The projects have been aimed at solving the problems of basic research especially in mathematics, informatics and computer science in electrical engineering, bionics and biomedical engineering. The VEGA projects delivered significant results of basic research primarily in the form of scientific publications, allowed participation of PhD students and young researchers and helped to facilitate the preparation of new scientific topics for large domestic and international projects:

- [16] VEGA project No. 2/7081/27 (Optical frequency stabilization of diode lasers by means of saturated absorption method, length standard implementation)
- [17] VEGA project No. 2/7082/27 (Infrared methods of measurement and non-destructive testing – active infrared thermography, reflectography and thermometry)
- [18] VEGA project No. 2/7083/27 (HTc Bulk Superconductors – Precursors, Technologic Procedures, Measuring Methods and Properties)
- [19] VEGA project No. 2/7084/27 (Methods and systems for contactless measurement of iron content in the liver)
- [20] VEGA project No. 2/7087/27 (Advanced methods of classification and prediction of attention decrease and sleep stages based on EEG analyses)
- [21] VEGA project No. 2/5043/27 (Specific Imaging Methods Based on Magnetic Resonance)
- [22] VEGA project No. 2/7092/27 (Measurement and model-based analysis of bioelectric fields)
- [23] VEGA project No. 1/3016/06 (New nonlinear methods of mathematical statistics II)
- [24] VEGA project No. 2/0142/08 (Imaging of Micro- and Nanostructures Based on Magnetic Resonance for Biomedical and Material Research)
- [25] VEGA project No. 2/0160/08 (Eye movement control: behavioural and electrophysiological markers of normal and pathological functioning)
- [26] VEGA project No. 2/0133/08 (Activity in a catecholaminergic system in hypergravitation)
- [27] VEGA project No.1/0077/09 (New Methods of Mathematical Statistics II)
- [28] VEGA project No. 2/0019/10 (Advanced classification and prediction methods in biosignal analysis and biologically inspired computer vision)
- [29] VEGA project No. 2/0101/10 (Progressive methods of measurement and nondestructive testing - active infrared thermography and X-ray)
- [30] VEGA project No. 2/0160/10 (Application of SQUID magnetometry and magnetic resonance in evaluation of efficiency of the gene therapy using magnetic nanoparticles)
- [31] VEGA project No. 2/0210/10 Methods and systems for multichannel measurement and evaluation of bioelectric signals of heart and brain
- [32] VEGA project No. 2/0020/11 The added value of chemistry for the knowledge and development of i) novel autoclaved aerated concrete and ii) macrodefectfree (MDF) materials.)
- [33] VEGA project No. 2/0090/11 Measuring and Imaging Methods Based on Magnetic Resonance for Material and Biomedical Research

## ii. List of national scientific conferences (co)-organised by the Organisation

- [1] The use of modern non-destructive measuring methods in research of new materials in the Centre of Excellence CEKOMAT, February 17, 2011 Bratislava, Slovak Republic

## iii. List of national journals published by the Organisation

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## iv. List of edited proceedings of national scientific conferences/events

- [1] The use of modern non-destructive measuring methods in research of new materials in the Centre of Excellence CEKOMAT, editors: M. Hain, K. Karovič, J. Jerz. Bratislava: Institute of Measurement Science SAS, 2011, 100 s. ISBN 978-80-969672-3-0.

## • International/European position of the individual researchers

### i. List of invited/keynote presentations at international conferences, documented by an invitation letter or programme

- [1] ŠVEHLÍKOVÁ, Jana. Multiple dipole model of the heart and its projection in BSP maps. In High resolution ECG and MCG mapping : 94th ICB Seminar. Warsaw, Poland, November 15-18, 2007.
- [2] TYŠLER, Milan. Body surface mapping – historical background. In 34th International Congress on Electrocardiology and 48th International Symposium on Vectorcardiography. Istanbul, Turkey, June 27-30, 2007.
- [3] TYŠLER, Milan. Experimental results of noninvasive identification of local ischemia using dipole models and HR ECG mapping. In High resolution ECG and MCG mapping : 94th ICB Seminar. Warsaw, Poland, November 15-18, 2007.
- [4] WITKOVSKÝ, Viktor. Metódy výpočtu porovnávacej referenčnej hodnoty v medzilaboratórnych porovnávacích experimentoch. In REQUEST '06 : 1. konference Centra pro jakost a spolehlivost výroby. ČVUT, Praha, ČR, 30.1.-1.2.2007.
- [5] FROLLO, Ivan. Gradient and shimming coil systems design, calculation and optimisation methods for low magnetic fields MRI. In PHeLiNet - Polarized Helium Lung Imaging Network : Lung Imaging with Hyperpolarised Helium-3 Magnetic Resonance. Paris, France, January 21-26, 2008.
- [6] GRENDÁR, Marián. Maximum probability and relative entropy maximization. In Bayesian Maximum Probability and Empirical Likelihood : International Workshop in Applied Probability IWAP2008. Compiègne, France, July 7-10, 2008.

- [7] ŠVEHLÍKOVÁ, Jana – TYŠLER, Milan – TURZOVÁ, Marie – HEBLÁKOVÁ, Eva. Possible noninvasive identification of small single or double lesions from variations in surface cardiac electric field. In 100th ICB Seminar : Variability of Biomedical Signals. Warsaw, Poland, November 20-23, 2008.
- [8] TURZOVÁ, Marie, TYŠLER, Milan, HEBLÁKOVÁ, Eva, ŠVEHLÍKOVÁ, Jana. Influence of heart rate variability on the accuracy of noninvasive detection of ischemic lesions. In 100th ICB Seminar: Variability of Biomedical Signals. Warsaw, Poland, November 20-23, 2008.
- [9] FROLLO, Ivan. Metódy zobrazovania na báze magnetickej rezonancie - alternatívy, trendy, perspektíva. In Trends in Biomedical Engineering : 8th Czech-Slovak Conference. Bratislava, Slovak Republic, September 16-18, 2009.
- [10] KRAKOVSKÁ, Anna. Discrimination ability of individual measures used in sleep stages classification. In From Nonlinear Dynamics to Biomedicine : Summer School. Université de Rouen, France, September 1-4, 2009.
- [11] TYŠLER, Milan. Modeling of cardiac electrical activity as possible tool for diagnostics of heart diseases. In YBERC 2010 : The 4th Biomedical Engineering Conference of Young Biomedical Engineers and Researches. Košice, Slovak Republic, July 1-3, 2010.
- [12] WIMMER, G. - WITKOVSKÝ, Viktor - WIMMER G. Jr. Continuation of Professor Kubáček's research work: Some miscellaneous examples. In Olomoucian Days of Applied Mathematics ODAM 2011 : The International Conference. Department of Mathematical Analysis and Applications of Mathematics, Faculty of Science of the Palacky University in Olomouc, Czech Republic, January 26-28, 2011.
- [13] WITKOVSKÝ, Viktor. On generalized likelihood approach and its applications. In XLI International Biometrical Colloquium and Czech-Slovakian-Polish Workshops on Biometry. Lublin, Poland, September 5-8, 2011.
- [14] WITKOVSKÝ, Viktor. Statistical inference for linear regression based on quantized observations. In International Conference on Mathematical Sciences (ICMS) in Honour of Professor A.M. Mathai. St Thomas College Palai, Mahatma Gandhi University, Kottayam, Kerala, India, January 3-5, 2011.

**ii. List of employees who served as members of the organising and/or programme committees for international conferences**

- [1] I. Frollo – 8 activities
- [2] M. Tyšler – 6 activities
- [3] V. Witkovský – 5 activities
- [4] J. Bartl - 2 activities

- [5] M. Hain – 3 activities
- [6] K. Karovič – 1 activity
- [7] J. Maňka - 3 activities
- [8] P. Andris - 3 activities
- [9] K. Bartošová- 3 activities
- [10] A. Dvurečenskij- 1 activity
- [11] M. Chvosteková- 1 activity
- [12] V. Juráš- 3 activities
- [13] J. Přibil- 5 activities
- [14] R. Ševčík- 2 activities
- [15] M. Škrátek- 2 activities
- [16] S. Štolc- 2 activities
- [17] M. Teplan- 1 activity

**iii. List of employees who served as members of important international scientific bodies (e.g. boards, committees, editorial boards of scientific journals)**

- [1] J. Bartl:  
Member of the Committee of the CS section of The International Society for Optical Engineering SPIE.  
Member of the Coordination board of the International Laser Centre  
Member of the editorial board of the journal: Fine mechanics and optics, AV ČR Praha.  
Member of European Optical Society  
Member of Slovak optical committee  
Member of Editorial Board: Measurement Science Review
- [2] K. Karovič:  
Member of the DAAD commission for joint Slovak-German projects
- [3] Frolo:  
Member of the IMEKO TC-7 committee  
Chairman of Slovak technical subcommittee IMEKO TC-7 Measurement Science  
Vice-president of the URSI subcommittee  
Chairman of the committee nr. 10 Electromagnetics in Biology and Medicine for SR  
Member of Central European Academy of Science and Art (CEASA)  
Member of IEEE Engineering in Medicine and Biology Society  
Member of IEEE Magnetics Society  
Member of the International Committee on Measurements and Instrumentation (ICMI)  
Editor-in-Chief: Measurement Science Review
- [4] M. Tyšler:  
Member of the committee: International Council of Electrocardiology  
President of the Slovak IMEKO TC-13 committee  
Member of IEEE Engineering in Medicine and Biology Society  
Member of IEEE Measurement Society  
Member of International Society of Electrocardiology



- Chairman of the Slovak IMEKO Committee and TC-13 Committee Measurement in Medicine and Biology  
Member of Editorial Board: Measurement Science Review
- [5] I. Bajla  
Member of Editorial Board: Measurement Science Review
- [6] L. Ondriš:  
Member of the Committee for coordination of cooperation SR with SUJV Dubna
- [7] V. Zrubec:  
Member of TSC4/IMEKO
- [8] F. Hanic:  
Member of external Nominator Group for Nobel Prize for Chemistry (the nominations approves "Nobel Committee for Chemistry. The Royal Swedish Academy of Sciences")  
Member of Regional committee of Slovak and Czech crystallographers, Crystallographic Society
- [9] J. Maňka:  
Member of European Society for Applied Superconductivity  
Member of Materials Research Society
- [10] J. Volaufová:  
Member of American Statistical Association, Secretary/ Louisiana Chapter of the ASA  
Member of Institute of Mathematical Statistics  
Member of Mathematical Association of America  
Member of Bernoulli Society for Mathematical Statistics and Probability  
Member of American Mathematical Society  
Member of Editorial Board: Measurement Science Review  
Member of the editorial board of the journal Acta et Commentationes Universitatis Tartuensis de Mathematica
- [11] V. Witkovský  
Member of Bernoulli Society for Mathematical Statistics and Probability  
Member of Biometric Society  
Member of International Association for Breath Research  
Executive editor: Measurement Science Review  
Member of the editorial board of the journal Acta et Commentationes Universitatis Tartuensis de Mathematica  
Member of the editorial board of the journal Colloquium Biometricum
- [12] I. Capek:  
Member of Indian Society for Surface Science and Technology (ISSST), India
- [13] J. Holčík:  
Representant of IFMBE in UNIDO

#### **iv. List of international scientific awards and distinctions**

- [1] J. Volaufová: Selected as a Fellow of the American Statistical Association (ASA). Júlia Volaufová has been selected for her excellence in the application of statistics and collaboration on research in biomedical fields; solicitous and challenging training of graduate students and professionals; organization of multiple international conferences; and persistent, effective efforts to preserve and promote the statistics community in the former Czechoslovakia and Central Europe.

- **National position of the individual researchers**

- i. **List of invited/keynote presentations at national conferences documented by an invitation letter or programme**

- [1] BARTL, Ján. Meranie dĺžky a geometrických veličín. In Meranie dĺžky a kalibrácia meradiel dĺžky v praxi. Detva, SR, september 2008.
- [2] BARTL, Ján. Realizácia jednotky dĺžky. In Seminár metroológov. Strečno, SR, 15.-16.10.2008.
- [3] BARTL, Ján - HAIN, Miroslav. Fyzikálne metódy prieskumu umeleckých diel. In Reštaurovanie a prírodné vedy. Vysoká škola výtvarných umení v Bratislave & Central European Institute of Art on Paper Conservation, Bratislava, 9.-11.4.2008.
- [4] GRENDÁR, Marián. Nazretie do modernej aplikovanej štatistiky. In 40. konferencia slovenských matematikov. Slovenská matematická spoločnosť pri JSMF. Jasná, SR, 27.-30.11.2008.
- [5] HAIN, Miroslav – BARTL, Ján. Kontaktné a bezkontaktné meranie povrchovej teploty. In Seminár metroológov. Strečno, SR, 15.-16.10.2008.
- [6] HAIN, Miroslav – BARTL, Ján. Rádiometrické metódy merania teploty. In XXVIII. zhromaždenie KZ SR. Hotel Tatranské Zruby, SR, apríl 2008.
- [7] GRENDÁR, Marián Jr. Bayesovská štatistika. In PRASTAN 2009. Kočovce, SK, 10.-12. jún 2009.
- [8] ŠTOLC, Svorad - BAJLA, I. Nové metódy rozpoznávania Epo v laboratórnej praxi. In Seminár komisárov dopingovej kontroly ADA SR. Trenčianske Teplice, SK, 28.-30. máj 2009.

- ii. **List of employees who served as members of organising and programme committees of national conferences**

- [1] I. Frollo – 1 activity
- [2] M. Hain- 1 activity
- [3] J. Bartl- 9 activities

- iii. **List of employees serving in important national scientific bodies (e.g. boards, committees, editorial boards of scientific journals)**

- [1] J. Bartl:
  - Member of the board of the International Laser Centre
  - Member of the editorial board of the journal Metrology and Testing
  - Chairman of the advisory board of Slovak Metrological Society
  - Member of Slovak Physical Society

- Member of Slovak Optical Committee  
Member of Scientific collegium for mathematics and physics
- [2] Frolo:  
Member of the scientific board of the Slovak Institute of Metrology  
Member of Society for Medical Physics and Biophysics, SMS  
Member of Slovak Metrological Society  
Member of Slovak Cybernetic Society  
Member of committee Society for Biomedical Engineering and Medical Informatics
- [3] J. Volaufová:  
Member of the editorial board of the journal: Tatra Mountains Mathematical Publications
- [4] V. Witkovský:  
Member of the Commission for Biometrics of the Slovak Academy of Agricultural Sciences  
Member of Union of Slovak Mathematicians and Physicists Bratislava I
- [5] M. Tyšler:  
Scientific secretary of the Society for Biomedical Engineering and Medical Informatics  
Member of Slovak Society of Cardiology  
Member of Slovak Metrological Society  
Member of the editorial board of the journal Metrology and Testing  
Member of the scientific board of the Slovak Institute of Metrology  
Member of Society for Medical Physics and Biophysics, SMS  
Member of Society for Biomedical Engineering and Medical Informatics, SMS
- [6] K. Hornišová  
Member of Union of Slovak Mathematicians and Physicists Bratislava I
- [7] M. Grendár  
Member of Union of Slovak Mathematicians and Physicists Bratislava I  
Member of the editorial board of the journal: Acta Universitatis Mathiae Belii Series Mathematics
- [8] P. Billik  
Member of Slovak Chemical Society
- [9] J. Maňka  
Member of Society for Biomedical Engineering and Medical Informatics, SMS
- [10] J. Přibil  
Member of Society for Biomedical Engineering and Medical Informatics, SMS
- [11] P. Torok  
Member of Slovak Spectroscopy Society
- [12] I. Capek

Member of Journal of Surface Science and Technology

[13] J. Holčík

Member of The Clinician and Technology Journal

#### **iv. List of national awards and distinctions**

- [1] F. Hanic: Honorary membership in Crystallography Society, Slovak and Czech Crystallographers (2007)
- [2] I. Frollo, K. Karovič, M. Tyšler: Diploma, acknowledgement for active work in Scientific Board of the Slovak Institute of Metrology, by the occasion of 40 anniversary of Czech- Slovak Institute of Metrology establishment
- [3] V. Witkovský: Diploma, Merited member of the Union of Slovak Mathematicians and Physicists (2008)
- [4] Frollo Ivan: Award of the Presidium of the SAS (2009)
- [5] Gold Medal of the SAS: For lifelong work in science (2009)
- [6] A. Kulišov: Memorial Plaque of the SAS (2009)
- [7] Tyšler Milan: Honour Plaque of Aurel Stodola, for credits in technical sciences, awarded by SAS
- [8] Bartl Ján: Gold Medal of ZSVTS (2011)

#### **v. Supplementary information and/or comments documenting international and national status of the Organisation**

The national as well as the international status of the Institute strengthened during the assessed period 2007-2011. This was reflected in increased number of domestic projects, bilateral and multilateral international projects and scientific cooperation, and successful participation (as a partner and WP leader) in two FP6 EU projects. The long term scientific cooperation with international partners allowed participation in many new proposals of bilateral and multilateral projects, including the FP7 EU projects (e.g. the projects focused on modern methods for evaluation of electrophysiological signals, development of statistical methods for analysis of exhaled breath data, carcinoma screening based on exhaled breath, phenotyping of genome-based biomarkers for patient stratification using exhaled breath diagnostics; and genome-based biomarkers for patient stratification and pharmacogenomic strategies). Intensive contacts with international scientific and professional societies remained at high level.

International recognition and respect of the scientific community has been achieved also by the conferences MEASUREMENT and PROBASTAT regularly organized by IMS SAS as well as by the journal Measurement Science Review published by the Institute in cooperation with Central European Science Publisher Versita Ltd. London, Great Britain,

and supported by the Slovak National Committee of IMEKO. In the assessed period the Journal was indexed by Thomson Reuters' ISI Web of Knowledge, Index Copernicus International, Scopus, Electronic Journals Library, Electronic Journals Index, The Summon, ProQuest, MetaPress, and EBSCO Publishing. In 2010 the Journal received its first impact factor from Thomson Reuters at level of 0,400 (IF2010), which is a very promising result in this field of science.

At the national level, there has been an extensive scientific and pedagogical cooperation with the most respected universities (Comenius University in Bratislava, Slovak Technical University in Bratislava, Technical University of Košice, University of Žilina), scientific institutions (Institutes of Slovak Academy of Sciences, Slovak Institute of Metrology), partners from industry (ENEL, NPP Jaslovské Bohunice, NPP Mochovce), cultural and healthcare institutions. The number of common laboratories, partnerships in scientific projects and collaborations has increased during the assessed period.

#### 4. Project structure, research grants and other funding resources

- **International projects and funding**

- i. **List of major projects within the European Research Area – 6th and 7th Framework Programme of the EU, European Science Foundation, NATO, COST, INTAS, CERN, ESA etc. (here and in items below please specify: type of project, title, grant number, duration, total funding and funding for the Organisation, responsible person in the Organisation and his/her status in the project, e.g. coordinator, work package leader, investigator)**

- [1] Type: 6<sup>th</sup>FP, “Integrating and strengthening the ERA”  
 Title: Breath-gas analysis for molecular-oriented detection of minimal diseases (BAMOD)  
 Grant number: LSHC-CT-2005-019031 STREP  
 Duration: 2/2006 – 1/2009  
 Total Funding: 2 998 228.00 EUR  
 Funding for the Org.: 58 025,65 EUR  
 Responsible: Assoc. prof. RNDr. Viktor Witkovský, PhD.  
 Status in the project: Work package leader
- [2] Type: 6<sup>th</sup> FP, Polarized Helium Lung Imaging Network  
 Title: Polarized Helium Lung Imaging Network (PHeliNet)  
 Grant number: 036002-2  
 Duration: 03/2007 - 02/2011  
 Total Funding: 148546,83 €  
 Funding for the Org.: 76979,- €  
 Responsible: Prof. Ing. Ivan Frollo, DrSc.  
 Status in the project: Investigator

- [3] Type: COST  
 Title: European Network for Hyperpolarization Physics and Methodology in NMR and MRI  
 Grant number: TD1103  
 Duration: 7/2011- 10/2015  
 Total Funding:  
 Funding for the Org.: 0,- € (2011)  
 Responsible: Prof. Ing. Ivan Frollo, DrSc.  
 Status in the project: Investigator

**ii. List of other international projects incl. total funding and funding for the Organisation**

- [1] Type: Cooperation in Science & Technology  
 Title: Statistical toolbox for analysis of exhaled breath data  
 Grant number: APVV SK-AT 0003-08  
 Duration: 01/2009 - 12/2010  
 Total funding:  
 Funding for Org.: 2884.19 €  
 Responsible: assoc. prof. RNDr. Viktor Witkovský, PhD., coordinator  
 Status in the project: Coordinator
- [2] Type: Cooperation in Science & Technology  
 Title: Improvement and development of high-resolution ECG measurement and processing methods  
 Grant number: TÁMOP 4.2.2  
 Duration: 2/2011- 5/2011  
 Total funding:  
 Funding for Org.: 7300 €  
 Responsible: Assoc. Prof. Milan Tyšler, PhD.
- [3] Type: Cooperation in Science & Technology  
 Title: Apparatus for Nuclotron magnetic field control  
 Grant number: 08626319/071849, 08626319/1020110-74  
 Duration: 01/2005-06/2008, 1/2010-12/2011  
 Total funding:  
 Funding for Org.: 35616,31 €  
 Responsible: Ing. Ľubomír Ondriš  
 Status in the project: Investigator
- [4] Type: Cooperation in Science & Technology  
 Title: Development of new sensoric microsystems for precise non-invasive monitoring  
 Grant number: ICE008PE  
 Duration: 2/2011- 8/2011  
 Total funding:  
 Funding for Org.: 4900 €  
 Responsible: Assoc. Prof. Milan Tyšler, PhD.  
 Status in the project: Investigator

**iii. List of other important projects and collaborations without direct funding**

- [1] Type: Bilateral Cooperation in Science & Technology

- Title: Research and Applications on HTc-superconductor  
Duration: 1/1999 – (not limited)  
Responsible: RNDr. Alexander Cigáň, CSc.  
Status in the project: Coordinator  
Partner: Research Group on Solid State Chemistry and Ceramic Superconductors, Department of Inorganic and Physical Chemistry WE06V, University of Ghent
- [2] Type: Bilateral Cooperation in Science & Technology  
Title: Development of the advanced optical measurement methods for nanoelectronics  
Duration: 01/2007- (not limited)  
Responsible: RNDr. Miroslav Hain  
Status in the project: Coordinator  
Partner: Nanoelectronics Research Institute of the National Institute of Advanced Industrial Science and Technology, Tokyo, Japan
- [3] Type: Bilateral Cooperation in Science & Technology  
Title: Modern methods for evaluation of electrophysiological signals  
Duration: 07/2008- 12/2008  
Responsible: ass. prof. RNDr. Viktor Witkovský, PhD.  
Status in the project: Coordinator  
Partner: Institute of Computer Science, CAS
- [4] Type: Bilateral Cooperation in Science & Technology  
Title: Diagnostics of tissues using contrast agents for biological and medical purposes  
Duration: 09/2006 - 08/2008  
Responsible: Prof. Ing. Ivan Frollo, DrSc.  
Status in the project: Coordinator  
Partner: Univ.-Prof. Dr. Siegfried Trattnig, MR Center, Highfield MR, Department of Radiology, Medical University of Vienna, Vienna, Austria
- [5] Type: Bilateral Cooperation in Science & Technology  
Title: High resolution measurement and model based analysis of cardiac electric field  
Duration: 01/2007- 12/2009  
Responsible: Assoc. Prof. Milan Tyšler, PhD.  
Status in the project: Coordinator  
Partner: Institute of Biocybernetics and Biomedical Engineering, Polish Academy of Sciences, Warszawa, Poland
- [6] Type: Bilateral Cooperation in Science & Technology  
Title: Research of the cardiac electric field  
Duration: 01/2007- 12/2009  
Responsible: Assoc. Prof. Milan Tyšler, PhD.  
Status in the project: Coordinator  
Partner: Institute of Normal and Pathological Physiology SAS Bratislava, CRIP Research Institute for Material Science and Technical Physics, Hungarian Academy of Sciences, Budapest, Hungary
- [7] Type: Bilateral Cooperation in Science & Technology  
Title: Noninvasive measurement and information analysis of bioelectric signals

- Duration: 10/2001- (not limited)  
 Responsible: Assoc. Prof. Milan Tyšler, PhD.  
 Status in the project: Coordinator  
 Partner: Laboratory of Bioelectric Information Processing, Institute for Problems of Information Transmission, Russian Academy of Sciences, Moscow, Russia
- [8] Type: Bilateral Cooperation in Science & Technology  
 Title: Research and education in the field of biomedical engineering  
 Duration: 06/2005- 8/2011  
 Responsible: Assoc. Prof. Milan Tyšler, PhD.  
 Status in the project: Coordinator  
 Partner: Department of Biomedical Technology, Faculty of biomedical engineering, CTU in Prague, Kladno, Czech Republic
- [9] Type: Bilateral Cooperation in Science & Technology  
 Title: Optical and magnetic methods in the elaboration and characterization of thin films of metallic oxides  
 Duration: 1/2008- 12/2009  
 Responsible: RNDr. Alexander Cigáň, CSc.  
 Status in the project: Coordinator  
 Partner: Institute of physics, PAS
- [10] Type: Bilateral Cooperation in Science & Technology  
 Title: Modern methods for evaluation of electrophysiological signals  
 Duration: 1/2009- 12/2011  
 Responsible: assoc.prof. RNDr. Viktor Witkovský, PhD.  
 Status in the project: Coordinator  
 Partner: Institute of Computer Science, CAS
- [11] Type: Bilateral Cooperation in Science & Technology  
 Title: Model based analysis and diagnostic interpretation of cardiac electric field measured by high-resolution ECG  
 Duration: 1/2010- 12/2012  
 Responsible: Assoc. Prof. Milan Tyšler, PhD.  
 Status in the project: Coordinator  
 Partner: IBIB PAN Warszawa, Poland
- [12] Type: Billateral Cooperation in Science & Technology  
 Title: Measurement and Information Processing for Diagnostic Imaging of Cardiac and Brain Electrical Fields  
 Duration: 1/2010- 12/2012  
 Responsible: Assoc. Prof. Milan Tyšler, PhD.  
 Status in the project: Coordinator  
 Partner: MFA KFKI Budapest, Hungary
- [13] Type: Billateral Cooperation in Science & Technology  
 Title: Diagnostics of human articular cartilage using MRI  
 Duration: 8/2006- 12/2012  
 Responsible: Prof. Ing. Ivan Frollo, DrSc.  
 Status in the project: Investigator  
 Partner: Department of Radiology, Medical University of Vienna, Austria. Univ.-Prof. Dr. Siegfried Trattnig.



- **National projects and funding**
- i. **List of projects supported by the European Social Funds (ESF) and Structural Funds of EU and the role of the Organisation**

Start	Project title	Project number	Duration month/year-month/year	Funding for Organisation within 2007-11 (EUR)	Role of the Organisation
2007 and earlier	Education of PhD students and technical workers for research, development, innovation, and application in measurement science	ESF 13120200032	08/2005 - 07/2008	123796,044	Coordinator
	MediTech - innovation program for modern biomedical technologies	ESF 13120200086	07/2006 - 02/2008	0,000	Investigator
	Building of a top laboratory aimed at NMR research	2003SP20028 0203	12/2006 - 6/2011	321705,5	Work package leader
2008					
2009	Creation of CE for research and development of construction composite materials for mechanical and civil engineering and medical applications	ITMS-26240120015	6/2009- 2/2011	24946,040	Work package leader
	Centre of Excellence for New Technologies in Electrical Engineering	ITMS – 26240120011	6/2009 - 5/2011	834,980	Work package leader
2010	Creation of CE for research and development of construction composite materials for mechanical	ITMS – 26240120020	9/2010- 12/2012	0,000	Work package leader
	Centre of Excellence for New Technologies in Electrical Engineering II	ITMS – 26240120019	3/2010- 2/2012	336000,050	Work package leader
2011	Centre of competency for new materials, advanced technologies and power engineering	ITMS-26240220073	08/2011 - 12/2012	0,000	Investigator

**ii. List of projects supported by APVV and the role of the Organisation**

Start	Project title	Project number	Duration month/year-month/year	Funding for Organisation within 2007-2011 (EUR)	Role of the Organisation
2007 and earlier	Application of magnetic and electric measuring methods in non-invasive examination of liver and heart	APVV-51-059005	05/2006- 06/2009	87799	Coordinator
	Statistical methods and algorithms for exhaled breath analysis	APVV- RPEU-008-06	02/2007- 01/2009	13869,940	Coordinator
2008	Electro-chemical biosensors based on nanobiocomposites for quick and efficient analysis of technology-important and health-important components of food and beverages	VMSP-P-0052-07/Nanobiosen	1/2008- 12/2009	7933,350	Investigator
2009	Statistical toolbox for analysis of exhaled breath data	SK-AT-0003-08	2/2009- 6/2011	2884,190	Coordinator
	Pocket analytical device for easy and quick analysis in the field of food industry and diagnostics, based on the single-shot biosensors with the use of nanotechnology	VMSP-P-0073-09/BioSenSys	9/2009- 8/2011	10000,000	Investigator
	Confidence regions for variance components	LPP-0388-09	9/2009- 8/2012	33642,000	Coordinator
2010					
2011	Measuring, communication and information systems for monitoring the cardio-vascular risk in hypertension patients	APVV-0513-10	05/2011 – 06/2014	23047,000	Coordinator
	Statistical methods for uncertainty analysis in metrology	APVV-0096-10	5/2011- 10/2014	23858,000	Coordinator

**iii. Number of projects supported by the Scientific Grant Agency of the Slovak Academy of Sciences and the Ministry of Education (VEGA) for each year, and their funding**

VEGA	2007	2008	2009	2010	2011
number	8	9	9	7	7
funding in the year (EUR)	45243	51318	46820	70172	70575

- **Summary of funding from external resources (based on annual financial report of the Organisation)**

External resources	2007	2008	2009	2010	2011	total	average
external resources (milions of EUR)	0,463	0,313	0,250	0,168	0,348	1,542	0,308
external resources transfered to cooperating research organisations (milions of EUR)	0,007	0,007	0,000	0,000	0,057	0,071	0,014
ratio between external resources and total salary budget	0,854	0,547	0,422	0,275	0,600	–	0,540
overall expenditures from external as well as institutional resources (milions of EUR)	1,248	1,117	1,087	1,063	1,259	5,775	1,155

#### iv. Supplementary information and/or comments on research projects and funding resources

Overall number of funded projects increased by almost 40% compared to previous assessment period. However, due to the missing calls of the Slovak Research and Development Agency (APVV) in 2008 and 2009 the total funding in years up to 2010 decreased significantly and was only recovering in 2011 after the call in 2010. The available calls in the period 2008-2009 for bilateral international cooperation projects with limited funding and/or the projects to support postdoc positions were not sufficient to substitute the missing calls for scientific projects with adequate funding.

The positive result of the assessed period is that 2 European projects and 1 COST were supported. Moreover, we got support for 2 projects from the European Social Fund and for 1 State R&D project.

Another positive result of the assessed period is the participation of the Institute in 4 project consortia for building the infrastructure (1 State R&D project, 3 ERDF projects). However, because of their administrative limitations some infrastructure could not be obtained by our Institute as a partner. In this way big capital investments within the State R&D project (Esaote tomograph for **321,400 € in 2009**) and ERDF projects (Nanotom microtomograph for **486.000 € in 2010**) that were obtained and are managed by our Institute are in fact not visible in the financial tables.

## 5. Organisation of PhD studies, other pedagogical activities

### i. List of accredited programmes of doctoral studies (as stipulated in the previously effective legislation as well as in the recently amended Act on the Universities)

Doctoral study accredited in accordance with the recent Act on the Universities:

5.2.54 Meracia technika (Measurement Technology) – accredited since March 29, 2006 as external educational institution of the Slovak Technical University in Bratislava, Faculty of Electrical Engineering and Information Technology for both, internal and external study program. In 2009 the Institute was re-accredited for this study according the law for the next 6-year period.

### ii. Summary table on doctoral studies (number of internal/external PhD students; number of students who completed their study by a successful thesis defence; number of PhD students who quitted the programme)

PhD study	31 12 2007			31 12 2008			31 12 2009			31 12 2010			31 12 2011		
number of potential PhD supervisors	9			9			11			12			12		
PhD students	number	defended thesis	students quitted	number	defended thesis	students quitted	number	defended thesis	students quitted	number	defended thesis	students quitted	number	defended thesis	students quitted
internal	7	0	3	2	1	6	4	4	0	5	3	0	5	2	0
external	4	0	0	4	0	0	3	1	0	3	1	0	1	1	1
supervised at external institution by the research employees of the assessed organisation	3	0	0	4	0	0	5	0	0	5	4	0	3	1	0

### iii. Postdoctoral positions supported by

#### a) external funding (specify the source)

[1] Project of the Slovak Research and Development Agency (APVV), LPP-0388-09 "Confidence regions for variance components", aimed to support postdoctoral position of Mgr. B. Arendacká, PhD. during the period 09/2009 - 08/2012. The total financial

support from the Slovak Research and Development Agency was 11184,- EUR (including personal costs 5600,- EUR for the postdoc position).

***b) internal funding - the Slovak Academy of Sciences Supporting Fund of Stefan Schwarz***

no

**iv. Summary table on pedagogical activities in undergraduate programmes for each year**

Teaching	2007	2008	2009	2010	2011
lectures (hours/year)	262	344	202	154	219
practicum courses (hours/year)	46	426	218	229	69
supervised diploma works (in total)	6	11	10	13	7
members in PhD committees (in total)	9	7	7	8	5
members in DrSc. committees (in total)	2	2	0	0	0
members in university/faculty councils (in total)	2	1	2	4	3
members in habilitation/inauguration committees (in total)	1	3	4	6	4

**v. List of published university textbooks**

- [1] BACHRATÝ, H. – GRENDÁR, Marián Jr. - BACHRATÁ, K. Ako sa počíta pravdepodobnosť? 1. edition, Žilina : Žilinská univerzita, 2010. 326 s. ISBN 978-80-554-0226-0.

**vi. Number of published academic course books**

- [1] Biosignály : školiaci materiál projektu ESF „Meditech : inovačný program moderných biomedicínskych technológií“. Projekt SORO/JPD-26/2005. Vedúci projektu J. Labuda. Editor F. Lehocki, M. Tyšler. Bratislava : Slovak University of Technology, 2008.

### **vii. List of joint research laboratories/facilities with the universities**

- [1] Scientific-technical and Pedagogic Laboratory for Engineering Surveys- common laboratory of Institute of Measurement Science SAS and Department of Theoretical Geodesy, Faculty of Civil Engineering, Slovak University of Technology in Bratislava.
- [2] Common Laboratory for Physical Survey of Object of Art- joint activity of Institute of Measurement Science SAS and Department of Restoration, Academy of Fine Arts and Design in Bratislava
- [3] Faculty of Mechanical Engineering STU and Faculty of Electrical Engineering and Information Technology STU in the framework of Centre of Non-Standard Measurements (with residence at the Institute of Measurement Science).

### **viii. Supplementary information and/or comments on doctoral studies and pedagogical activities**

We have obtained two projects from the European Social Fund: MediTech and MerTech. These projects enabled to admit and finance 5 additional PhD students and to gain funds for advanced education. Both project were realized in cooperation with Slovak University of Technology.

In July 2009 the IMS SAS was reaccredited in the PhD study program "Measurement Technology".

The employees are pedagogically active at Slovak University of Technology in Bratislava, Comenius University in Bratislava, Matej Bel University in Banská Bystrica, Czech University Of Technology in Kladno (CZ) and Brno University of Technology (CZ).

## **6. Applied research**

### **i. List of the most important results of applied research projects and their socio-economic impact**

- [1] Optoelectronic systems for tilt measurement of nuclear reactors in power stations  
Systems for nuclear reactor tilt monitoring were developed and installed in nuclear power stations Nuclear Power Plant Mochovce 1, 2 and Nuclear Power Plant Bohunice 3, 4 in Slovak Republic and are being routinely used for several years.  
Modified systems for Nuclear Power Plant Mochovce 3, 4 are being developed and prepared for installation in this power plant in cooperation with VUJE Trnava. Applicator: Slovenské elektrárne.
- [2] Nanotechnology based pocket analytical device for easy and fast analysis in the food industry and diagnostics, based on the single-shot biosensors

Multi-microprocessor electro-chemical compact device, that allows in-field measurement of selected analytes of wine and food. Device is equipped with simple user-friendly interface, which allows performing of quick analysis using single-shot biosensors. Device has built in USB 2.0 interface and dedicated software that allows transferring of measured data into the PC for further post-processing.

Applicators: Slovak University of Agriculture in Nitra as well as commercial wine producers in the region of Karpaty.

[3] Development and production of mechanical parts for the special optoelectronic measuring probes

Institute of Measurement Science realized development and production of mechanical parts for special optoelectronic measuring probes and their compositions. It was produced on the basis of the treaty on cooperation. These probes are intended to measure the shape of complex castings in the automotive industry.

Applicator: Datalan it works, Inc.

[4] Measurement of the thermal resistance of aluminium

The new method which is designed and developed for an automated measuring system for measurement of thermal resistance of aluminium radiators for power electronic components

Applicator: GAMA aluminium, Ltd., Žiar nad Hronom

[5] Optical sensor for the fast testing of the machine engineering production.

Cooperation is focused on the design and implementation of the optical methods for testing micro-defects on functional surfaces of special components. The priority focus is on applications in precision engineering, automotive and in bearings industry.

Laser scattering sensor for testing micro-defects on surface was developed in the year 2007. This sensor was realised in coaxial arrangement This sensor was part of the test equipment developed by Mesing up the shaft to the International engineering fair in Brno, where he won the Gold Medal of the fair 2007.

Applicator: Mesing, Ltd., Brno, Czech Republic

[6] Kit of digital radiological system, X-ray CT tomograph

Radiological system of a new generation with the energetic separation of detected photons, X-ray source having a small focus (in order of 10  $\mu\text{m}$ ) and automatically controlled positioning for scanning and tomography.

Applicator: MAGIC TRADING CORPORATION, a. s. Liptovský Mikuláš.

[7] Non-destructive testing of historical artefacts

In order to apply the results of our research and in collaboration with the restorer academic painter Miroslav Surin we have used several optical non-destructive methods - infrared reflectography, ultraviolet fluorescence and infrared thermography for testing of cultural heritage artefacts - the wall paintings in Bratislava castle before and during the reconstruction of it.

Use of infrared reflectography and digital image processing allowed the dotted underdrawings visualisation. Underdrawings were drawn by painters on the wall before painting, and they are valuable information for restorers and testimony of any changes in the compositions of the murals. Use of ultraviolet fluorescence with digital image processing allowed visualisation of later over-paintings and retouching of murals.

Applicator: Restorers of the Bratislava castle.

[8] X-ray microtomography

As part of the project VEGA "Progressive methods of measurement and non-destructive testing - active infrared thermography and X-ray microtomography" as well as within the project of the Structural funds "CEKOMAT " the methodology of an optimized 3D visualization of internal structures of selected objects in the field of materials research, microelectronics, electronics, mechatronics, mineralogy, geology and biology has been proposed. The effect of spectral composition of the X-ray radiation on the optical contrast of X-ray projections was theoretically analysed. Alpha

Further, the control options of the spectral composition using accelerating voltage in the X-ray tube, choice of material of targets (tungsten, molybdenum) and an X-ray beam filtration were analysed.

They were also developed methods of 3D visualization of microstructures and image segmentation; and the possibilities of metrological calibration of the microtomograph for the purposes of measurement of internal structures were analysed. The achieved results were verified experimentally, presented at conferences and published in periodicals.

Applicator: research results are used for optimization of X-ray microtomographic techniques and are applied in cooperation with other institutes, universities and industry.

**ii. List of the most important studies commissioned for the decision-making authorities, the government and NGOs, international and foreign organisations**

- [1] BARTL, J.: Evaluation report of project within Slovak office of standards, metrology and testing
- [2] Frollo, I.: Review of international scientific project. Grant agency of Czech Republic, Application for a Grant, Reg. No.: 102/08/0691: „Visualization and processing of 3D images captured by a confocal microscope using graphics processor unit programming and virtual reality”
- [3] WITKOVSKÝ, V.: Review of international scientific project. Grant agency of Czech Republic, The Institute of Information Theory and Automation CAS: “Compositional models”, Reg. No.: 201/08/0206. 24.10.2007
- [4] WITKOVSKÝ, V.: Review of international scientific project. Grant agency of Czech Republic, The Institute of Information Theory and Automation CAS: “Conditional independence structures: graphical and algebraic approaches”, Reg.No.: 201/08/0539. 24.10.2007
- [5] WITKOVSKÝ, V.: Evaluation report of international scientific project. The research proposal submitted to the Oesterreichische Nationalbanks Anniversary Fund for the Promotion of Scientific Research and Teaching - Jubiläumsfonds zur Förderung der Forschungs- und Lehraufgaben der Wissenschaft



- [6] KAROVIČ, K.: Evaluation report of 21 projects within DAAD
- [7] WITKOVSKÝ, V.: Evaluation report of 1 project within The Ministry of Education, Youth and Sports, Czech Republic
- [8] TYŠLER, M.: Evaluation report of 9 projects within European Science Foundation / Fundamentals of Nanoelectronics

### **iii. List of patents issued abroad, incl. revenues**

There were 2 patents registered in the Czech Republic within the assessed period (see part III.1.vii). The Institute did not have revenues from these patents within the assessed period.

### **iv. List of the patents issued in Slovakia, incl. revenues**

There were 6 patents registered in Slovakia within the assessed period (see part III.1.vii). Following of them brought some income:

- [1] Rosík, Vladimír - Kulišov, Andrej - Tyšler, Milan - Hána, K. - Kneppo, P. Active electrode for measuring of bioelectric signals (Aktívna elektróda na snímanie bioelektrických signálov). Industrial design no. SK 5598 Y1. Date of entry into effect of the industrial design: 30.9.2010. Owner: Faculty of Biomedical Engineering CTU in Prague, Kladno, CR; Institute of Measurement Science SAS, SR.

Revenues: 2482 €

### **v. List of licences sold abroad, incl. revenues**

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### **vi. List of licences sold in Slovakia, incl. revenues**

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### **vii. List of contracts with industrial partners, incl. revenues**

- [1] Development and production of mechanical parts for the special optoelectronic measuring probes, Co-operation with Datalan it works, Inc., Slovak Republic (6126 €)
- [2] Calibration, service and maintenance of nuclear reactors 3, 4. Co-operation with Nuclear Power Station Jaslovske Bohunice (19521,55 €)
- [3] Calibration, service and maintenance of nuclear reactors 1, 2. Co-operation with Nuclear Power Station Mochovce (19650,55 €)
- [4] Calibration, service and maintenance of nuclear reactors 1, 2. Co-operation with Nuclear Power Station Mochovce (12367,86 €)
- [5] Calibration, service and maintenance of nuclear reactors 3, 4. Co-operation with Nuclear Power Station Jaslovske Bohunice (16233,34 €)

### viii. List of research projects with industrial partners, incl. revenues

- [1] Measurement the thermal resistance of aluminum, Co-operation with GAMA aluminium s. r. o. , Žiar nad Hronom, Slovak Republic (1 875 €)
- [2] Optical sensor for the fast testing of the machine engineering production, Co-operation with Mesing, Ltd., Brno, Czech Republic (4502 €)
- [3] Systems for nuclear reactors 1, 2 tilt monitoring. Co-operation with Nuclear Power Station Mochovce (5137,30 €)
- [4] Modernization of program equipment, Nuclear reactors 3,4, Co-operation with Nuclear Power Station Jaslovske Bohunice (7000 €)
- [5] Cooperation with VUJE, development of new systems for monitoring of the tilt of nuclear reactors 3, 4 in Nuclear power plant Mochovce (20160 €)

### ix.

Outreach activities	2007	2008	2009	2010	2011	total
studies for the decision sphere, government and NGOs, international and foreign organisations	4	4	7	11	10	36

## 7. Popularisation of Science

### i. List of the most important popularisation activities

- [1] Regular presentations and lectures presenting the research results and its applications for public during the “Open Days at the Institute of Measurement Science”. The action is organized regularly each year within the “European Science Week” and “Science Week Slovakia” organized by Slovak Ministry of Education and the Slovak Academy of Sciences, 2007-2011.
- [2] Excursions for university students presenting research activities and laboratories of the Institute, organized with co-operation with Žilina University in Žilina, 2007-2011.
- [3] Presentation of research results and its applications through Night of Scientist, Avion Shopping Centre, Bratislava, September 23, 2011
- [4] Press release- Scientists from SAS contributed to improving detection of doping in athletes, tasr 06.11.2007, (V. Witkovský)
- [5] Interview about new detection methods beginning of cardiac ischaemia, 13.11.2007; The radio station “Slovensko”; 10.10; 19,5 min.; HÍLEK Martin, MICHALIČOVÁ Viera. (M. Tyšler)
- [6] Interview, In the Institute of Measurement Science, Bratislava opened a center for nuclear magnetic resonance, 11.3.2009, The radio station “Slovensko” (Prof. Ing. Ivan Frollo, DrSc.)
- [7] TV report, Synchronization frequency of brain waves with partners, 25.11.2009 Television news TV JOJ (RNDr. Anna Krakovská, CSc.)

- [8] Internet report SAS awarded work of Ivan Frollo, 1.2.2010 [www.veda.sme.sk](http://www.veda.sme.sk), [www.news.sk](http://www.news.sk), [www.boinc.sk](http://www.boinc.sk), [www.scienceweek.cz](http://www.scienceweek.cz) (Prof. Ing. Ivan Frollo, DrSc.)
- [9] TV report- New laboratory X-ray microtomography- opening ceremony, 8.11.2010 STV 1 (Mgr. Robert Ševčík, PhD.)
- [10] Press- 8. International conference about measuring– Measurement 2011- Metrology and testing journal 4/2010, (M. Tyšler)
- [11] TV Document- Magnetic resonance- discovery of the century, 1.6.2011 Slovak television (Prof. Ing. Ivan Frollo, DrSc.)
- [12] TV report- Jumping cockroaches (scientists super discovery)- News Tv Joj, 19:30, 26.7.2011 (RNDr. Miroslav Hain, PhD.)
- [13] Short document- Magnetotherapy, TV Joj, 24.7.2011 (Prof. Ing. Ivan Frollo, DrSc.)
- [14] Austrian-Slovak seminar for students "Sparkling Science: FEM Trace Conference" organized in cooperation with Breath Research Institute of the Austrian Academy of Sciences, held at the Institute of Measurement Science SAS, Bratislava on June 9, 2011.

#### i. Summary of outreach activities

Popularisation of science	2007	2008	2009	2010	2011	total
articles in press media/internet popularising results of science, in particular those achieved by the Organization	3	11	10	18	4	46
appearances in telecommunication media popularising results of science, in particular those achieved by the Organization	9	0	7	3	4	23
public popularisation lectures	5	3	8	3	5	24

#### ii. Supplementary information and/or comments on popularisation activities

Besides the popularization activities aimed at presenting current scientific results among the public, in the period 2007-2011, we have taken a special interest in promoting the research in the field of measurement science and its application for talented students and young scientists with the aim to attract them as possible future PhD students. The Institute was co-organiser of the Austrian-Slovak seminar for students of the grammar schools, entitled "Sparkling Science: FEM Trace Conference Bratislava", which has been held at the Institute of Measurement Science on June 9, 2011. The seminar was organized by the Breath Research Institute of the Austrian Academy of Sciences, Dornbirn, Austria, and the Institute of Measurement Science in co-operation with the Mathematical Institute of the Slovak Academy of Sciences, Bratislava and the Faculty of Natural Sciences, Comenius University, Bratislava. The aim of the seminar was to popularize science and its applications, especially for talented students of the grammar schools in Austria and Slovakia. The seminar was attended by many students of the Bundesgymnasium Dornbirn,

Gymnasium Adolf Pichler Platz, Innsbruck, Gymnázium Jura Hronca, and Gymnázium Grösslingová 18, Bratislava.

## 8. Background and management. Staffing policy and implementation of findings from previous assessments

### i. Summary table of personnel

Personnel	2007	2008	2009	2010	2011
all personnel	85	82	81	75	72
research employees from Tab. Research staff	60	58	58	54	49
FTE from Tab. Research staff	32,5	37,4	37,26	36,82	32,21
average age of research employees with university degree	47,5	46,5	46	46,2	42,9

### ii. Professional qualification structure

Number of	2007	2008	2009	2010	2011
vedúci vedecký pracovník DrSc./ research professor DrSc.	5	6	4	3	2
Vedúci vedecký pracovník CSc., PhD/research professor CSc., PhD	3	3	3	4	3
samostatný vedecký pracovník/ senior scientist	11	8	9	8	10
vedecký pracovník/research scientist	13	13	16	22	19
profesor/professor	2	3	3	3	4
docent/assoc. prof.	7	8	7	7	6

*Vyplňte podľa prílohy A, správy o činnosti organizácie.*

### iii. Status and development of research infrastructure incl. experimental, computing and technical base (description of the present infrastructure, premises, and material and technical resources. Infrastructure, instrumentation and major technical equipment necessary for the achievement of the objectives specified in the research Concept)

In the assessment period the IMS SAS gained several unique advanced devices. They were financed by National Centre of NMR (Centre of Excellence) and by projects of the European Structural Funds. However, it was necessary to invest additional funds to implement these equipment and they are still needed for their proper operation.

Gained new equipment

- **NMR imager by ESAOTE – Opera** with permanent magnet 0.178 Tesla, intended for biomedical and material research and for research in the field of nanotechnology. This device is a property of Slovak University of Technology, however, fully managed by the Institute.
- **Computer microtomograph GE Phoenix X-ray Nanotom 180** with resolution (200-300 nm) and detector resolution 2300x2300 pixels with 8 PC cluster and specialized software. It enables 3D analysis of materials structures, electronic and mechanical parts, biological objects, archaeological artefacts, etc. This device is a property of Institute of Materials and Machine Mechanics SAS, however, fully managed by the Institute.
- **SQUID magnetometer/susceptometer MPMS-7XL-AC** produced by Quantum Design with 7 Tesla superconducting magnet, operating in the temperature range 1.9 – 400 K. Its limit sensitivity for magnetic moment is  $10^{-11}$  Am<sup>2</sup>. It is intended for biomedical and material research.

Other most important devices and laboratories are:

- **Detached laboratory for measurement of extremely weak magnetic fields** (home made SQUID gradiometric system with equivalent sensitivity of  $\sim 20 \times 10^{-15}$  T Hz<sup>-1/2</sup> in the white noise range, cryogenic equipment) – it includes a biomagnetic laboratory.
- **Laboratory of Magnetic Resonance Imaging.** The laboratory is equipped with the whole-body experimental scanner TMR 96, 0.1 Tesla, 6-coil resistive water cooled magnet, high stability and field homogeneity of the basic magnetic field. 14 – coil system for magnetic field correction, control console: S.M.I.S., gradient amplifiers: Tegmag, RF transmitter: 2 kW, operational frequency 4.45 MHz, RF coils for whole body and head imaging and special small dimensional high sensitive coils for imaging with high resolution.
- **Laboratory of synthesis of high-temperature superconducting materials.**
- **Optical laboratory:** optical-fibre spectrometer, low power HeNe and diode lasers, optical power meters, choppers, lock-in amplifiers, CCD cameras, digital oscilloscope, laboratory optical tables, set of refractive and reflective optical elements and filters, wave retardation plates, optical insulators. The laboratory is also equipped with: external cavity diode laser 633 nm, which can be used for high resolution spectroscopy and stabilisation of optical frequency in the order 10<sup>-11</sup>, and thermographic camera

- **Laboratory for biomedical measurements** equipped with specialized devices developed also within research and technology projects (ProCardio 8, EGG - ProGastro 3, BioLab ATR, BioLab STI).

Other devices owned by our partners within several consortia in EU Structural Funds projects and are placed in the Institute. They are also at disposal for our research:

- **FIB microscope QUANTA 200 3D** for scanning and shaping of nanostructures (Institute of Electrical Engineering SAS),
- **Scanning electron microscope JEOL JSM-7600F** for samples up to 200 mm with ultra-high resolution and detectors for secondary electrons, backscattered electrons, EDS, WDS, EBSD, CL (Institute of Materials & Machine Mechanics SAS),
- **Bruker AXS – D8 Super Speed Diffraction System** for research of thin layers, multilayers and supermatrices in nano-scales (Institute of Electrical Engineering SAS),

#### iv. Status and development of bibliographic resources, activities of the Organisation's library and/or information centre

The library contributes to the central account of the publication activity of the Slovak Academy of Sciences (EPCA) – 1908 records and to the electronic catalogue of books (ARL) – 3528 records. These are accessible on the web.

Number of books and journals:

	2007	2008	2009	2010	2011
Books	13 513	13 532	13 538	13 557	13 557
Journals	17	16	14	14	10

The number of subscribed periodicals decrease as the research workers have an access to increasing number of on-line full-text databases.

Provided services:

- bibliographic information
- literature search from the electronic databases
- lending journals, books
- reprography services

Other activities:

- account of the publication activity and citations

**v. Describe how the results and suggestions of the previous assessment were taken into account**

The main suggestions of the previous assessment can be summarised as follows:

1. To form coherent research program oriented to progressive trends of research and to reduce diversity of research aimed at higher quality of research outputs, better response and improved success rate of project proposals.
2. To insist on requirements of excellence and high quality research and to stimulate all teams to publish the results in high quality journals.
3. To increase the number of projects in the EU Frame programs.
4. To increase the number of PhD students and their incorporation into the Institute after finishing the PhD study.
5. To pay attention to management and marketing of intellectual property, including specialised institutions
6. To increase investments into the infrastructure.

Response:

1. During the assessed period the management of the Institute succeeded to reduce the diversity of research and to concentrate the research activities of the scientific departments to few selected areas in accordance with the stated Concept for R & D. The current research focus can be shortly characterised as a basic and applied research in the field of measurement science, non-destructive material testing and non-invasive diagnostics. This research focus is in agreement with the current priorities in Slovakia and orientation of SAS (new materials, biomedicine). Successful inclusion of the Institute into 4 large project consortia also helped in concentration to these main topics.
2. In order to improve quality of the research outputs, the management of the Institute incorporated the partial indicators of the accreditation criteria directly into the system of yearly evaluations of the scientific departments and individual researchers. Economical stimulation of the departments and individual researchers was directly related to the regular ratings of the scientific level and quality of the research output.
3. During the assessed period Institute participated in two EU FP6 projects and participated in four submitted and evaluated proposals of the EU FP7 projects (one the proposals is currently evaluated in 2<sup>nd</sup> stage of the evaluation procedure):
  - 'EXHALOMICS - Comprehensive breath analysis for non-invasive diagnostic profiling', FP7-HEALTH-2010.1.2-1, coordinator: Prof. J. Schubert, University of Rostock, Germany.

- 'EU13C - Phenotyping of genome-based biomarkers for patient stratification using exhaled breath diagnostics', FP7-HEALTH.2011.1.1-2, coordinator: Prof. A. Amann, Innsbruck Medical University, Austria.
  - 'BREATHS - Breathing: Experimental and Analytical Technologies for Hospital-based Studies', FP7-HEALTH.2012.1.2-1, coordinator: Prof. C. L. Paul Thomas, Loughborough University, UK.
  - 'STRAT-VOC - Predicting individual drug responses using CYP450 phenotyping-based patient stratification through the development of breath tests', FP7-HEALTH.2012.1.2-1, coordinator: Prof. A. Amann, Innsbruck Medical University, Austria.
4. The number of PhD students is limited by the quota within SAS (one, but with permission of the SAS Presidium two students per year). To increase this limit, the Institute used also available positions within the EU FP and EU ERDF projects (2 positions) and offered also external study for students accepted as Institute employees. In this way 9 new PhD studies started, 12 PhD students successfully finished their studies. The Institute offered positions to 11 of them, currently 8 of them are employed in the Institute.
  5. The teams were stimulated to protect the intellectual properties of the researchers what resulted in 8 registered patents (against 2 in the previous period). Currently the Institute has signed partnership and prepares agreement with Technological Institute of SAS for cooperation in intellectual property protection.
  6. A lot of effort was devoted to inclusion of the Institute into project consortia that were in the assessed period practically the only possibility for building new infrastructure. As mentioned in the text, we happened to become partners in 4 such projects what helped us substantially improve the infrastructure of the Institute as mentioned in part III.8.iii.

#### **vi. Supplementary information and/or comments on management, research infrastructure, and trends in personnel development**

There were two changes in the Institute management during the assessed period in positions of the head of Department of Magnetometry and in Section of Economics and Administration. The main tasks of the management, except those suggested by the accreditation committee, were to improve the personal structure and to maintain and reconstruct the existing Institute's infrastructure. Including the building of the Institute.

As already stated, the Institute's infrastructure has improved substantially, namely due to the State R&D project and several ERDF projects. Total investments were about 1.204 mil. € compared to 0.064 mil. € in the previous period. However, because of the administrative limitations of the projects, larger part thereof (0.807 mil. €) came through partner institutes.



Besides that the whole exterior of the building (partially with a help from central financing) and part of the interior was reconstructed, another part is prepared for reconstruction within an ERDF project.

With the exception of the period of the economic crisis, due to the economic conditions, it was difficult to attract high quality PhD students. We think that foreign students are only partial solution to this problem (our student left after the study). Because of generally much better conditions abroad it was also difficult to upkeep the postdocs, moreover, also due to the same criteria for all disciplines, we were not able to get single support from the Schwarz fund and some our best postdocs left for abroad where they are very successful.

Despite these problems we were quite successful in improving the personnel structure of the Institute: although the total number of employees decreased from 85 to 72, the number of researchers remain nearly the same (from 35.5 to 35.2), their mean age decreased (to 42.9, all from 47.6 to 47.1, scientists from 54.8 to 47.4) and the number of scientific co-workers substantially increased (from 17.1 to 26.6).

**9. Supplementary information and/or comments important for the assessment of organisation which are not explicitly mentioned in the questionnaire (concerning each previously mentioned evaluation criteria, facts not included, evaluation of research teams by ARRA, etc.)**

**Other information relevant to the assessment**