Evaluation of the Research and Professional Activity of the Institutes of the Czech Academy of Sciences (CAS) for the period 2010–2014

Final Report on the Evaluation of the Institute

Name of the Institute: Institute of Scientific Instruments of the CAS, v. v. i.

Fields, in which the Institute registered its teams:

Materials engineering, materials science and nanotechnology ,Metrology and diagnostic methods

Observer representing the Academy Council of the CAS: Jiří Chýla
Observer representing the Institute: Pavel Zemánek, substitute observer Pavel Jurák

Commission No. 8: Engineering and technology
Chair: em Prof.DI.Dr.Dr.hc. Hans Peter Nachtnebel

Date(s) of the visit of the Institute: October 12 - October 21, 2015
Programme of the visit of the Institute: see attached Minutes from the visit

Evaluated research teams:
No. 1 - Electron microscopy; No. 2 - New technologies; No. 3 - Magnetic resonance and cryogenics; No. 4 - Medical signals; No. 6 - Coherents optics

EVALUATION OF THE INSTITUTE OF SCIENTIFIC INSTRUMENTS

This report refers to the Evaluation of the Institute Scientific Instruments (ISI) of the Academy of Sciences of the Czech Republic, 2010-2014, and is written according the to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS. This evaluation is based on the materials provided from the Institute of Scientific Instruments and from their particular departments, from the web pages [www.isibrno.cz], from particular presentations, and last but not least from discussions with researchers and management of the Institute (all within the "on site visit" on October 19, 2015).

1. INTRODUCTION

1.1 Location of the institute and its dept., labs. & sub units.

Name: Institute of Scientific Instruments of the CAS, v. v. i.
Address: Královopolská 147, 612 64 Brno, Czech Republic
Director: Dr. Ilona Müllerová, DrSc.
Deputy Director for Research: Prof. Pavel Zemánek
Deputy Director for Executive Affairs: Dr. Bohdan Růžička, MBA
Brno, the second largest city of the Czech Republic, has a population of nearly 370,000 people. It lies in the central part of Europe and within its two hundred-kilometer radius there are other important European capitals: Prague, Vienna and Bratislava. The international airport in Brno serves regular flights.
Brno is the metropolis of Moravia and an important center and seat of universities and important judiciary institutions. The Brno Exhibition Centre with its eighty-year tradition is a venue of many international trade fairs, exhibitions and congresses, and as such plays a significant role in Europe.
The town of Brno is the town of six universities: Brno University of Technology, Masaryk University, Mendel University in Brno, University of Veterinary and Pharmaceutical Sciences Brno, Janáček Academy of Music and Performing Arts in Brno, and University of Defense.
South Moravian Region is a region with significant economic potential. The gross domestic product of the region represents one tenth of the gross domestic product of the Czech Republic. Due to the industrial tradition Brno still has a dominant position in the regional manufacturing economy. The key parts of modern history of Brno, in terms of economic development, were mainly engineering and textile industry. New industrial zones in close surroundings are growing, often occupied with foreign companies oriented to logistical services, but also new, home grown small and medium enterprises are flourishing.

1.2 Brief history of the institute

The Institute of Scientific Instruments (ISI) was established in 1957 (from the Developmental Workshops of the Czechoslovak Academy of Sciences in Brno) as an institution providing instrumental equipment for other institutes of the Academy of Sciences in many areas. The Institute carries out research on physical methods, special technologies and unique instrumentation principles in the fields of electron optics and microscopy, nuclear magnetic resonance, bioinformatics and coherence light optics.
During the process of transformation of the Academy of Sciences, which began in 1989, only the most promising branches of scientific research were supported at the institute.

The structure of the scientific departments of the institute was also changed, so that it gained from the research activities of the projects solved by the research teams. The teams dealing with related problems are organized into departments.
[Based on materials provided and materials from www.isibrno.cz]

1.3 Mission and research topics

Position and mission of the Institute of Scientific Instruments (ISI)

ISI is a research institution specialized on the field of instruments and instrumentation technology. This specialization stretches from applied physics to technical sciences. The field of technical sciences always carries a significant portion of applied research in it and cannot be solely interpreted as pure, fundamental, or big science only.
Societal relevance in technical sciences primarily means a contribution to the competitiveness of the national economy through applied research in cooperation with industrial partners. In technical sciences a significant part of motivation comes from the application sector. The link to practice is in technical branch of research inevitable and deeply incorporated in any research strategy. In the field of instruments and instrumentation research the inspiration in research is a mixture of impulses coming from industry and from basic research. High-end instrumentation represents nowadays a key and determining tool in the process of understanding the universe.
ISI has established itself as a regional technology powerhouse. Long-term, focused and in-depth research in a series of selected research topics has helped ISI to open a number of fruitful collaborations with a large number of industrial partners in Czech Republic and abroad.

Research concept

The concept of doing research in ISI reflects the research specialization of ISI, its position in the society and its mission. Each department of the ISI as well as the institute itself is building its knowledge base, a core, representing a pool of knowledge, experience and technologies. This core is distributed within the research team which is always constituted as a set of specialists able to deliver a multidisciplinary approach to the solution of particular problems and projects.
The core also includes keeping and developing of specialized technologies supporting the research at ISI. The technology background is being built on the department level and at the institutional level where a principle of complementarity is maintained. This institutional technology background is the best representation of the interconnection and cooperation between the research departments and groups within ISI where the diversity of the topics seems to be apparent.
The building of the core pool of knowledge can be seen as the fundamental or basic component of the research done at ISI. Feeding the pool comes from the curiosity driven research in physics as well as applied physics and impulses coming from science and scientists using methods and associated instrumentation developed at ISI. The same way, applied research projects bring inspiration and experience that also contribute to the pool.
Particular research projects oriented to solution of specific tasks either in a form of collaborative applied research or fundamental research are strongly interconnected with the core through simultaneous feeding the pool and drawing from it. Extensive diversity of the research topics of the ISI and each department or group seen through the concept of core vs. periphery appears more or less virtual. Every project solved at ISI, with its specific goals to fulfill, is interlinked with any other through the core into a network research activities. This network of projects represents a framework of the ISI research concept of combining research excellence and societal relevance. Excellence lies in the cumulative, long-term building of the core pool of knowledge in a few specific fields of research and the relevance can be seen in dissemination of the knowledge through discrete and diverse projects reflecting specific tasks and problems to be solved. The projects at the same moment act in feedback and contribute to the core.
The long-term experience of ISI has led to a notion that too strong focus on a very narrow and clearly defined research topic bears the risk that the topic might become exhausted one day. The obligation to

the society to contribute to the national competitiveness, which is apparent in any technical sciences, motivates to preserve and care for the core pool of knowledge which should not be lost. The core, as it has been defined at ISI through virtual diversity of discrete but interlinked projects, is thus multigenerational and hopefully immune from twists and turns of the science fashion.

Research topics

The Institute of Scientific Instruments (ISI) is pursuing methodology oriented scientific research focused on new methods and techniques of investigation of physical properties of matter.

Therefore the Institute of Scientific Instruments goals are to perform scientific research on the development of new methods and associated special technologies and new instrumentation principles, to contribute to the utilization of its research and provide research infrastructure.

Part of its task is the construction of high-quality technical components and systems in the fields of ultra-high vacuum, cryotechnology and super-conductivity. Interdisciplinary research on the microstructure of matter is carried out in an attempt to obtain results that can have practical application in biology, chemistry, medicine, ecology and physics.

Main areas of the Institute of Scientific Instruments research (research topics) are

- magnetic resonance,
- electron microscopy and microanalysis,
- laser technology and photonics,
- acquisition and processing of biosignals,
- construction of scientific instruments and their parts,
- research and development of special technologies.

Activities of the Institute of Scientific Instruments

- Contribution to raising the level of knowledge and education and to utilizing the results of scientific research in practice
- Acquisition, processing and dissemination of scientific information and issuing scientific publications (monographs, journals, proceedings, etc.)
- Carrying out doctoral study programmes in cooperation with universities
- Training of young scientists
- Promoting of international cooperation within the scope of ISI activities
- Organization of scientific meetings, conferences and seminars at national and international level
- Providing infrastructure for research
- Pursuing ISI aims both independently and in cooperation with universities, other research and professional institutions and private companies

These activities are in:

- fundamental research
- applied research
- advanced engineering
- and they are interconnected by methodological activities.

All activities participate in the key outputs of ISI in the form of:

- publications
- applied outputs, mostly within collaborative research
- dissemination and knowledge + technology transfer
- contractual research for external partners

Each of the Research teams in the Institute deals with multidisciplinary topics covering: primarily physics and engineering with an extension to biology and medicine.

The Institute of Scientific Instruments cooperates with

- universities within doctoral study programmes and training of young scientists,
- foreign institutions within joint research projects, exchange of scientific information, and organization of scientific meetings,
- other research and professional institutions
- private companies

Involvement of the institute in the Strategy AV21 of the Czech Academy of Sciences

The Strategy AV21 consists of 14 multidisciplinary research programmes. Institute of Scientific Instruments has been involved in the constitution of the Strategy AV21 from its beginning and now director of ISI, Dr. Ilona Müllerová, is a coordinator of one of the programmes, called "Diagnostic Methods and Techniques". The programme reflects the long-standing tradition of the Czech Republic in the area of precise machinery, electronics, optics, special devices and corresponding advanced technologies and its goal is to uphold this tradition and extended it into other areas and further develop it at a cutting-edge level. Methodology oriented research represents also the fundamental methodological and instrumentational background for any research effort in any field of science and puts together all branches of science into one interdisciplinary framework with advanced technology and engineering. Nine other institutes of the CAS participate on the program "Diagnostic Methods and Techniques" and a number of high-tech Czech companies are associated with it as well.

1.4 Staff size and full time equivalents age distribution

The sum of the full time equivalents as of December 31, 2014
technical workers: 42.05
administrative workers: 32.10

Age structure of the Institute [under the Institute Report]

Age	<25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	>70
number	9	32	31	21	7	22	19	15	12	11	7

More than 1/3 employees involved in research are younger than 35 years and represent the pool for future group leaders and experts.
More than 1/2 employees involved in research are in the productive age (35-65) with deep experiences in their fields.
The rest of employees consist mainly of very important experts and emeritus scientists with broad experiences and skills that are dissipated to younger colleagues.
The age structure is **very well balanced** and with good prospect for the future.

Number of researchers – men and women [under the Institute Report]

	2010	2011	2012	2013	2014
Head count - sum	147	146	163	176	183
Head count - women	34	36	40	48	49
V - sum	83	88	95	101	106
V - women	11	11	14	14	16

O - sum	64	58	68	75	77
O - women	23	25	26	34	33
Ph.D. - sum	57	61	63	67	70
Ph.D. - women	5	4	3	4	5

Researchers are hired in accordance with art. 16 § 1 of the Act no. 283/1992 Coll**.,** on the Czech Academy of Sciences (CAS). The staff recruitment procedure is regulated by the Statutes of CAS:

- tender is announced by director upon the request of the head of department
- commission named by the director recommends a suitable candidate
- director determines positioning the new employee to the qualification grade and provides wage
- institute relies upon own education of future staff members starting from doctoral or even master studies.

The existing **Career Order** and the regular comparison of workers' **performance motivates well** the employees to continuously improve their qualification and to develop their skills and abilities. This is also facilitated by several factors:

- attestation commission recommendations,
- superiors' recommendations,
- participation in training, courses and conferences, the foreign or domestic business trips to other institutions

Researchers are ranked in the qualifying stages based on detailed rules specified for the classification of research workers; further, the ranking is based also on the evaluation and proposal of the attestation commission; the final rank being decided by the ISI director under rules of Art. 22 § 2 of the Annex to the Statutes of the CAS:
V1 *Research Assistant* - completed university studies
V2 *Ph.D. Student* - worker involved in doctoral studies
V3 *Postdoctoral Fellow* - worker who reached his Ph.D. or its equivalent, who works under the direction of a scientist and who independently achieves target objectives
V4 *Associated Scientist* - worker who after a period of 5 years from the acquisition of the scientific title is neither classified as the scientist nor the senior scientist
V5 *Scientist* - worker, who solves autonomously serious and complicated research tasks, and usually solves the grant projects
V6 *Senior Scientist* - researcher who is a leading scientific personality, who contributes to the development of the field internationally, and who usually leads the research team and/or is a member of an expert advice or council of CAS.
O *Nonscientific workers*

Number of researchers ranked in the qualifying stages (increase 25 %) [under the Institute Report]

	2010	2011	2012	2013	2014
V1 – Research Assistant	7.96	5.5	5.93	5.51	6.27
V2 – Ph.D. Student	13.78	13.21	14.47	17.08	20.7
V3 – Postdoctoral Fellow	17.24	17.08	14.74	13.99	12.03
V4 – Associated Scientist	12.72	16.25	19.48	20.14	16.97
V5 - Scientist	9.45	10.76	12.76	16.01	21.10
V6 – Senior Scientist	9.43	8.37	8.01	8.2	11

Total	70.58	71.17	75.39	80.93	88.07

2. STRENGTHS AND OPPORTUNITIES

2.1 Topicality of the research

The Institute deals with modern topics combining theoretical studies with numerical modelling and experimental studies with a direct impact on industrial applications. The research strategy relies on cumulative building of a knowledge base through fundamental research and dissemination through applied research within a framework of collaborative projects with industrial partners. This concept reflects also a combination of in-depth focus and diversity of projects. This **sophisticated** strategy produced the background of a number of excellent results. They represent top research in the current physics, engineering, material sciences with overlap into medicine, and biology. The general research topics are relatively stable. The research topics of all the departments are **industrially** extremely relevant. There are no weaknesses and threats related to research topics.

2.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

Situation in 2014:

The Czech Academy of Sciences funding	23 %
Other grants	44 %
Other revenues (mostly from depr. assets)	26 %
Contract research, own products and services	6 %

	2010	2011	2012	2013	2014
No applications	24	48	43	47	33
No granted projects	4	11	14	9	14
Rate of success	17%	23%	33%	19%	43%

The teams of the Institute acquire funding from contract research (industrial partners), from the Czech Academy of Sciences, the Technology Agency, the Czech Science Foundation, Ministry of Education, Youth and Sports, diverse national project calls, regional science support (South Moravia) and EU projects. The funding sources are diverse. This composition is not reasonable and optimal. Involvement in international projects is **significant and growing**. A great contribution was the EU project from structural funds **ALISI**. The ALISI project helped the institute to build new laboratories, purchase new, state-of-the-art equipment and hire young people.
The Institute would prefer a larger part of the funding provided directly by the Academy of Sciences, without competition. The evaluation commission understands that it would be much more comfortable for the institute to have a larger amount of non-competitive funding. However, in contrast to the opinion of the institute, the evaluation commission judges that the income sources of the institute are **well balanced** and are comparable to the repartition of a typical research group in mechanical, civil or chemical engineering at a university in western European countries. Other institutes have a similar complaint. Institute funding directly from the Czech Academy of Sciences on non-competitive basis is typically around 50%, where institutes would like to have it around 70 %. Very likely, 70 % non-competitive funding was a typical ratio until some years ago.

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

The research teams **collaborate intensively** with another departments and teams of the Institute, the collaboration among them depends on the current needs and possibilities, e.g., utilization of the special instruments, joint participation on the projects etc. Cooperation of the Institute with other research

subjects and universities both in the Czech Republic and around the world is very intensive and fruitful.
The institute has built a wide, long-term, and very good **network of cooperation** with universities, hospitals and companies. Due to its multidisciplinary orientation on methodologies, the institute **efficiently** cooperates with these partners that form the portfolio of end-users for the research.

2.4 Position of the institute within the Czech scientific community and its international position

The Institute of Scientific Instruments is leading in development of high-tech instruments. At the moment the Institute activities are balanced between the fundamental research and applied research together with development. Position of the Institute within the Czech scientific community in the aforementioned research areas in the top level and many of the research results obtained are **original and essential on an international scale**.

2.5 The overall capacity of staff

The Institute has 106 researchers, 70 Ph.D. students, 42 technical workers, and 32 administrative workers. Continually increasing number of employees during the evaluation period is obvious from materials provided. The gradual rise of the number of the staff is a result of long-term strategy to put together specialists in various fields to be able to face the interdisciplinary research problems. The capacity is very well composed and balanced.
All the areas of ISI research (electron microscopy and technologies, MR tomography and spectroscopy, cryogenics, laser applications, biosignal acquisition and processing) belong among **highly multidisciplinary** fields and ISI is active in this area for more than half a century. ISI represents a **unique place** where the fundamental research in selected areas of physics, chemistry, biology, medicine is directly combined with advanced engineering skills in machinery, electronics and programming on the long-term basis.

2.6 Reasonability of the structure of the institute and the departments

The structure of the Institute is based on historical development. The Institute consists of 6 scientific departments with 14 research groups. This structure is **reasonable**; it is based on the heterogeneity of the main individual research topics.
Single location is considered a **great advantage** for efficient cooperation across teams at multidisciplinary projects.
Reasonable number of employees, low fluctuation of employees and single location ensure that the employees and management know each other personally for reasonably long time to build very efficient way of cooperation and communication. This is an advantage of **efficiently manageable size** of the institute
Majority of buildings and rooms is gradually renovated; laboratories are being equipped with modern instruments and equipment. Relationships between ISI employees are **collaborative**, **fair and supportive**. This leads to increasing attention of high-quality students and researchers to work at ISI and makes the institute very attractive workplace.

2.7 Comments on the age structure

Age structure of all Institute employees is summarized in the table below. Structure of employees from point of view of their age is as follows: More than 1/3 employees involved in research are **younger** than 35 years and represent the pool for future group leaders and experts.
More than 1/2 employees involved in research are in the **productive age** (35-65) with deep experiences in their fields.

The rest of employees consist mainly of very important experts and emeritus scientists with broad experiences and skills that are dissipated to younger colleagues.

Age structure od the Institute [under the Institute Report]

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number	9	32	31	21	7	22	19	15	12	11	7

Very good age structure of the scientific teams with increasing number of research members including young researchers makes a **promising background for the future** development of the Institute.

2.8 Frequency and quality of publications

Frequency of publications is **adequate** to the specific field of "Instruments and instrumentation research". Scientometric studies comparing domestic and international quality and amount of publications within narrow research specializations have shown that this publication activity is **well comparable** with the European standard. For many years the ISI was mainly focused on development of high-tech instruments. The publication quantity may look smaller compared to other branches of research, but in fact it reflects the way how research is done and published in this field.
During the 2010-2014 period, there were published papers in journals with IF (222 in total), papers in other journals (53 pieces), and papers at conferences (552). There were 9 patents and 199 applied results. In the Evaluation Phase I, 10 selected publications were classified as world-leading and 40 as internationally excellent.
However it seems that the Institute researchers **prefer quality to quantity** because averaged impact factor of ISI papers published in 2010-2014 is 3.1 which is well above the CAS average in applied physics (2.1, data taken from http://www.lib.cas.cz/arl).

9 Patents and role in contractual work

During the 2010-2014 period there are 9 patents and there is considerable contract research work. Contractual work is a source of significant incomes. The role of the Institute on contractual work is generally not related to patents but in the solution of practical problems. The amount of time and resources coming from contractual research is limited with respect of the other source of budget.
There are no weaknesses and threats related to patents.

3. WEAKNESSES AND THREATS

3.1 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The whole institute has a large portion of project funding which is unusual and maybe unique in the whole Czech Academy of Sciences. It is a product of the research environment in the Czech Republic with a large portion of purpose (project funding) and a historical evolution of the institute together with the contribution of the **EU project from structural funds ALISI**. The ALISI project helped the institute to build new laboratories, purchase new, state-of-the-art equipment and hire young people. This rise of the staff contributed to the overdependence of the institute on the project funding.
The diversity of project funding pushes the key researchers to spend enormous time searching for funding sources, writing project proposals and wasting time with project agenda. The low success rate of project calls make it even worse and rising vulnerability.
A threat, to which most research teams in western and middle Europe are confronted with, including the Institute of Scientific Instruments, is the tendency for reduction of the funding possibilities on the national level and thus continue involvement in projects with EU funding or international funding. The institute is fully aware of this necessity.

3.2 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

The staff is only partially international. The institute involves only a few foreign researchers – this number reflects on one hand a limited chance to attract foreigners from richer countries while keeping acceptable social balance between foreigners and Czechs at the corresponding level of work productivity and on the other hand still persisting will of native young people to do science. This, fortunately, makes this problem (at least in Brno) is not so significant. Fortunately the representatives of South Moravian Region are getting active in targeted help for high qualified foreigners and make this region more attractive for them to come and also stay longer.
It is quite common to consider teams with a large portion of foreigners as desirable. On the other hand it is questionable whether it is really an advantage or whether it is in the rich countries only a reflection of the fact that only a decreasing number of native young people are willing to do science. Here, fortunately, this problem (at least in Brno) is not so significant.

4. RECOMMENDATIONS

4.1 Re-organisation of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

At the moment we **do not recommend** some type of re-organisation of the internal structure of the Institute and departments. The Institute must be prepared to solve new research topics in future. For these purposes it is desirable to looking for other adequate personal and financial sources in the future.

4.2 Internal programs to stimulate actions to enforce strengths and to reduce weaknesses

Within the Institute they have various programs to enforce strengths and to reduce weaknesses. Emphasis is on contributions in high quality journals. There are internal programs and incentives to stimulate a conversion of results from conference contributions into regular journal articles. Focus on strengthening of international collaboration. The teams are under the supervision The Director and The Council.

4.3 Identification of new research topics

The Institute (ISI) research plan (for 2015–2019) consists of research plans of all teams described in details. The main goal is to utilize researches' intellectual potential and up-to-date equipment and enhance existing methods of investigation of nanoworld, microworld and macroworld in the relevant areas of physics, biology, medicine and engineering. There does not seem a direct need to search for another new research topics. These come spontaneously.

5. DETAILED EVALUATION

5.1 Declaration on the quality of the results and share in their acquisition

Characterisation of the main research activities (experiments, theoretical areas)

The main research activities of the Institute have **very complex** character and they include both very exact theoretical approaches and **sophisticated** experimental research. Main results can be shortly divided into several groups, reflecting the division of the Institute into Departments and groups.

Relevance in the national and international context

Research activities of the Institute have undoubtedly very important relevance not only in the national, but also in international context. Results were received within the frame of Czech research projects, international projects, and international cooperation.

Overall quality of publications

Scientific outputs of the Institute researchers have generally **very good quality**,
The majority of evaluated publications belongs to internationally (40) and nationally recognized outputs (39). Among world-leading publications there are 10 papers. Some papers (19) are published in top decile (1*) and quartiles 1-2 by AIS of journals (51 + 58). These facts were confirmed in the Evaluation Phase I. Also intensity of citations of these publications is on average level.
Publication activity of the Institute researches is **adequate** to the field of "Instruments and instrumentation research". and thus **well comparable** with the European standard. For many years the ISI was mainly focused on development of high-tech instruments. However it seems that the Institute researchers prefer **quality to quantity** because averaged impact factor of ISI papers published in 2010-2014 is 3.1 which is well above the CAS average in applied physics (2.1, data taken from http://www.lib.cas.cz/arl).

Specification of the main achievements

The overview of the main achievements is mentioned in the evaluation documents of the departments.

Specification of the contributions of the team to publications

Typical for the majority of outputs is a **high fraction** of work done only by members of the team including experiments, calculations, theoretical background and interpretation with rather limited international or national collaboration.

5.2 Declaration on the involvement of students in research

Involvement of students (doctoral, undergraduate) into research

Students are involved into the research of the institute within the frame of their bachelor, master and doctoral studies.
ISI CAS is not authorized to award academic titles (BSc, MSc, PhD) as such. It is however **accredited** as a scientific research workplace for the students of Masaryk University and Brno University of Technology. Experienced researchers at ISI CAS serve as students‘ PhD, MSc and BSc **supervisors**, approved by scientific boards at the respective universities.

- A supervised student’s entire scientific research is performed at the ISI, where the students spend most of their time.
- ISI strives to create **above-standard** conditions for the students:
- **Paid work contracts** as a bonus to the scholarship that students get at the university
- Participation at conferences
- Engagement in research projects
- Fellowships abroad
- Participation in Marie Curie Actions (PEOPLE) – ISI participates in 4 of these projects thanks to which we have 4 foreign students and a number of reciprocal stays abroad.
- Students are **significant contributors** to all scientific outputs at ISI CAS.

The institute during the period of 2010-2014 solved 24 joint grants with 14 different faculties belonging to 9 universities. There were six professors at the ISI in the reporting period.

Supervision of students

type of study	No of supervisors	No of consultants or co-supervisors	Theses defended in 2012-2014
Bachelor	40	40	43
Master	62	4	51
Doctoral (Ph.D.)	55	3	26

Particular contributions of students to research

Students generally work on topics of their supervisors. Students are **significant** contributors to all scientific outputs at ISI CAS.
In the framework of various national projects, many doctoral and undergraduate students are introduced into the joint research team. They can do very useful scientific work and help their advisors in their research tasks. Collaboration with doctoral and undergraduate students often results in publications co-authored by the students. This kind of collaboration with Universities is **very beneficial** for the both contracting parties.

Number of defended PhD students in relation to students involved (success rate)

Institute in collaboration with Universities has participated on Ph.D. student's education. Leading researchers are often supervisors of Ph.D. theses. PhD training has served the Institute as a hiring tool; Institute systematically tries to **increase jobs openings** for young scientists. In the period 2012-2012 in total 26 doctoral theses were successfully defended. The success rate of the Ph.D. study at the institute is **100%, or very close to 100%**. The numbers reported in table include those who entered the study within the evaluated period and did not finish it yet.

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type of study	No of supervisors	No of consultants or co-supervisors	Theses defended in 2012-2014
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Employment of former Ph.D. students (career options)

Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students, including female students, are now members of the research team. The former Ph.D. students can continue their contract as so-called "post-docs". The possibility to open new positions for postdocs within the departments of the institute is given by the **successes in grants** and projects which provide funding for them.

5.3 Declaration on societal relevance

Societal relevance in technical sciences primarily means a **contribution to the competitiveness** of the national economy through applied research in cooperation with industrial partners. In technical

sciences a significant part of motivation comes from the application sector. The link to practice is in technical branch of research inevitable and deeply incorporated in any research strategy. In the field of instruments and instrumentation research the inspiration in research is a mixture of impulses coming from industry and from basic research. High-end instrumentation represents nowadays a key and determining tool in the process of understanding the universe.
The institute is a well-established research institution in the region with a large network of cooperating partners from industrial **companies**. Some of them **even grew on the research** and know-how of the institute, particularly those dealing with **electron microscopy**. Thanks to the long-term history of research in electron optics at ISI the Brno region is now a world leader in production of electron microscopes. ISI keeps a close cooperation with these companies and also other high-tech firms in the region.

Impacts of the results and other activities on economy

The Departments have a **broad** collaboration with the industry and participate on solving of manufacturing problems of industrial partners and research institutes and universities within the frame of collaborative and contractual research. The institute follows a concept of balanced combination of **fundamental and applied research** with a direct link to many industrial partners that benefit very much through improvements of their competitiveness.
Research activities and their results have very strong impact on the Institute economy – both institutional and grant parts of the budget depend on the quantity and quality of the outputs. High level of the scientific work, experience of the researchers and many unique experimental instruments offer also very good opportunities for many students.
During the 2010-2014 period, there were the following **awards** given:

- Premium prize prof. Wichterle 2014 - Oto Brzobohatý and Jan Hrabina.
- Awards: "Czech Head" Invention category bestowed by the Kapsch company for: "Methodological research in electron microscopy Ilona Mullerová.
- Werner von Siemens excellence award 2013 in the category: „The most important result of the fundamental research“ - Demonstration of the optical tractor beams.
- Gold Medal 2012 International Engineering Fair in Brno and Werner von Siemens Excellence Award 2012 in the category: “The most important results of innovation”- System with automated control for Gauge blocks contact-less calibration.
- MIT PhysioNet Challenge Awards 2014 -False Alarms in Intensive Care Unit Monitors: Detection of Life-threatening Arrhythmias. Robust Multichannel QRS Detection.

Impacts of the results and other activities on education

The Institute contributes also to teaching on various levels. Researchers participate **actively** in educational bachelor, master and doctoral programs mainly at Masaryk University and Brno University of Technology. The involvement of departments in student supervision is also very good.

Impacts of the results and other activities on culture

This impact should be in the field of applies physics and technology seen through propagation and promotion of science especially of technical subjects, which is now a national priority. Popularisation of science is mentioned below.

Outputs providing information relevant for public policy decisions in all fields of life Services for research (libraries, data bases, collections,..)

The institute is not dealing with social sciences or humanities, so providing information for policy decisions is not relevant. The institute has a large library which can also be used by external researchers. There are various types of services for research.

Popularisation and similar activities

The Institute participates significantly in activities of popularisation of science. There are contributions to TV and radio programmes and it produces press releases: Czech TV (19), Czech Radio (8), Articles in newspapers and journals (12), Public lectures (7), Exhibitions (9), each year: Week of Science and Technology of the CAS, Visitor's Days of the ISI.
The evaluation commission judges the effort of the institute in science popularisation as very good and extensive.

5.4 Declaration on the position in the international and national context

Comparison of the position, recognition, outputs and impacts with leading and international teams

Position of the Institute in both national and international scientific community is very important. Research activities of the Institute have undoubtedly very important relevance not only in the national, but also in international context. The research work at the Institute is done within an international context and fits into the wider efforts in the fields of research covered by the ISI departments.

The Institute of Scientific Instrument is leading in development of high-tech instruments. At the moment the Institute activities are balanced between the fundamental research and applied research together with development. Position of the Institute within the Czech scientific community in the aforementioned research areas in the **top level** and many of the research results obtained are **original and essential on an international scale**. Position of the Institute in the international scientific community is strong and very important.

Role and position in international collaboration

The departments are already involved in a **number of international projects** and a **great amount** of informal international collaborations. The **integration** to wider international scientific networks already exists and is well established. The Institute should continue in this effort.

Breadth/completeness of the research activities compared to world leading teams of comparable size

The institute is to be compared to the similar European non-university research institutions dealing with research in the field of applied physics and technical sciences with an outreach to industrial applications and biology or medical oriented research as well as clinical practice. The institute puts together quite a **unique combination** of theoretical expertise, excellent technology background, top experimental capabilities technical design experience, realization equipment together with application skills reaching out from physics and technology (e.g. to medicine). This makes the comparison pretty difficult.
Considering the **whole portfolio of research outputs** including applied research, development of instrumentation, knowledge and technology transfer etc. the activities are in comparison with the leading European laboratories surely very good.

Ability to attract foreign researchers at different levels

The institute employs several foreigners. The amount may not look large, but it is **a** good number for the standards of the Czech Republic (and especially for Brno).
It is quite common to consider teams with a large portion of foreigners as desirable. On the other hand it is questionable whether it is really an advantage or whether it is in the rich countries only a reflection of the fact that only a decreasing number of native young people are willing to do science. Here, fortunately, this problem (at least in Brno) is not so significant.

Possible missing research directions

There are no missing research directions.

Position of the team in the national context

Position of the Institute in both national and international scientific community is very important. The Departments belong to leading groups at the national level with established collaborations with a number of Czech research teams mainly at universities. The number of research projects funded by grant agencies confirms this statement.

5.5 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience
The age structure of the institute is of a very good distribution including students, young researchers, post docs, research fellows and senior researchers with the best qualifications reachable in the Czech Republic, which is further improved by a direct collaboration with foreign institutes. The number of female researchers is **appropriate**.
The Institute provides financial incentives to research teams successful in solicitation research funding or contractual research.

Attraction of research programmes for young people

The research programmes seem very attractive for young people. The research groups use modern methods and unique facilities. Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good thanks to successes in acquiring project funding and thus the chance to create new positions for young researchers. Former students are becoming new members of the staff as “post-docs”.

Funding (structure of the resources and its comparison with the outputs, grants and project activity

The structure of funds is balanced with a good contribution from contractual research (about 6%) and national resources. The **structure of funds** of the institute is strongly **dominated by project funding**.

Effectiveness of research (based on comparing size of groups, funding and output)

The output of the institute seen through the number of overall outputs, including publications,

their quality, development of instrumentation and technologies, methodologies and applied research is very good. In technology oriented research the efficiency should be judged also through societal impact on the economy, which is very good (see above).

Organizational structure, recruitment methods, career system, incentives for females, young researchers, international researchers

Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students, including female students, are now members of the research team. The former Ph.D. students can continue their contract as so-called "post-docs". The chance for postdocs to become members of the staff is given by the ability of the researchers (primarily the senior researchers) to succeed in project proposals and to secure the **project funding** and **open new positions** as a result of this effort**.**

5.6 Declaration on the strategy and plans for the future

Relevance of the out lined strategy and research plans

Detailed research plan of the Institute for 3015-2019 is prepared in very great details. Plan of the Institute is especially based on its human resources and budget. The Institute will continue in a structure of existing research Departments. The basic policies of the Institute will be focused mainly on institutional support of grant applications, efficient use of existing experimental equipment, and support for the rising interdisciplinary research, openness towards commercialization of research results.

The key research strategy of the whole institute is to care and feed the core pool of knowledge, experience and expertise and to do project oriented research to solve specific tasks either in a form of collaborative applied research or fundamental research drawing from the pool. This network of projects represents a framework of the ISI research concept of combining research excellence and societal relevance. Excellence lies in the cumulative, long-term building of the core pool of knowledge in a few specific fields of research and the relevance can be seen in dissemination of the knowledge through discrete and diverse projects reflecting specific tasks and problems to be solved. The projects at the same moment act in feedback and contribute to the core.

The long-term experience of ISI has led to a notion that too strong focus on a very narrow and clearly defined research topic bears the risk that the topic might become exhausted one day. The obligation to the society to contribute to the national competitiveness, which is apparent in any technical sciences, motivates to preserve and care for the core pool of knowledge which should not be lost. The core, as it has been defined at ISI through virtual diversity of discrete but interlinked projects, is thus multigenerational and hopefully immune from twists and turns of the science fashion.

Adequacy of available means and human resources to achieve these plans

The capabilities of the existing research team are very good. Supplementary recruitment of researchers will be necessary. Obtaining supplementary funding will also be necessary.

The Institute wants to maintain the general organizational structure of the ISI departments, but to be flexible enough to support new scientific directions for strong individuals or projects, so that new groups can be formed. Also they want to follow the **healthy common sense** and keep a **friendly and cooperative atmosphere** at ISI so that everybody can enjoy the creative work.

Missing issues in the strategy

There are no missing issues, provided that the institute is serious about setting up strategic co-operations with foreign research teams with the objective of acquiring funding from EU sources.

EVALUATION OF THE INSTITUTE OF SCIENTIFIC INSTRUMENTS

Department of Electron Microscopy

This report refers to the Evaluation of the Institute Scientific Instruments (ISI) – Team of Electron microscopy - of The Czech Academy of Sciences (CAS), 2010-2014, and is written according to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS. This evaluation is based on the materials provided from the Institute of Scientific Instruments and from their particular Departments, from the web pages [www.isibrno.cz], from particular presentations, and last but not least from discussions with researchers and management of the Institute (all within the "on site visit" on October 19, 2015).

1. INTRODUCTION

There are 5 groups within the Team of **Electron microscopy (EM)**
1. Electron Optics
2. Microscopy and Spectroscopy of Surfaces
3. Microscopy and Microanalysis
4. Microscopy for Biomedicine
5. Environmental Electron Microscopy

1.1 Location of the institute and its dept., labs. & sub units.

Laboratories and the other facilities of this Team are in the main building of the ISI (Královopolská 147, 612 64 Brno).

1.2 Brief history of the Team

The history of Electron Microscopy at the Institute of Scientific Instruments was shaped by the students of prof. A. Bláha: A. Delong, V. Drahoš and L. Zobač. They built a desktop electron microscope (the Tesla BS 242), which won the Gold Medal at EXPO 1958. Over 1000 of these instruments were produced over a period of 20 years and exported to 20 countries. The electron microscopy developed significantly in the sixties thanks to the then director Prof. A. Delong and the head of the department of electron optics Prof. V. Drahoš. Unique transmission, emission and scanning electron microscopes were built and, at the same time, the problems of highly stabile current and high voltage sources, problems of vacuum and, subsequently, ultra-high vacuum and analysis of residual gases were resolved. In 1962 the first experiments with electron interferences anywhere in the world were carried out at ISI. One of the successful developed transmission microscopes was the TEM TESLA BS 413 with a resolution of up to 0.6 nm and accelerating voltage up to 100 kV, of which 400 were produced by the company TESLA Brno to the end of 1975. At that time non-conventional forms of electron microscopy were also developed, e.g. interference, shadow, Lorentz and tunnel emission

microscopy, as well as diffraction under small angles. The first experiments in the world and application possibilities of low-energy electron diffraction were demonstrated with the newly developed ISI electron microscope and were published by A. Delong and V. Drahoš in the journal Nature (1971).
Since 1973 the method of finite elements has been exploited for computation of electrostatic and magnetic rotation symmetric lenses. In the middle of the nineteen seventies a team was established, which produced an Auger electron spectrometer in connection with a newly developed scanning electron microscope with a field-emission gun, subsequently produced as the TESLA BS 350.
The development of new scintillation and cathodoluminescence screens began in the seventies. The introduction of a single crystal of YAG (Yttrium-aluminium-garnet) proved to be a particularly significant success within the scope of these efforts. The detectors based on this principle have become established around the world. Work in the field of environmental electron microscopy provided successful, especially in the area of electron detection in the environment of higher gas pressure.
Nowadays 30% of the word production of electron microscopes is developed and produced in Brno (FEI Czech Republic s.r.o., TESCAN, DELONG INSTRUMENTS a.s.), which is strongly influenced by the long term tradition of electron microscopy at ISI. Team of EM has close cooperation with all of them especially in the field of basic and applied research, as well as in the education of students. Several common projects were solved with these partners.
[Based on materials provided and materials from www.isibrno.cz]

1.3 Mission and research topics

Involvement of the department in the Strategy of the CAS AV21
The research programme "Diagnostic Methods and Techniques" of the new Strategy AV21 includes several research topics, or sub-programmes. The Department of Electron Microscopy is involved in one of them, called "Nanodiagnostics of structures and their creation using electron, ion and light beams", which is coordinated by Tomáš Radlička, head of the Department of Electron Microscopy, ISI together with Jan Lorinčík from the Institute of Photonics and Electronics, and David Hradil from the Institute of Inorganic Chemistry.

Group of Electron Optics

Mission of the group:
The members of the group are engaged in the study of electron optical elements and systems from both theoretical and practical point of view, aiming at the improvement of electron optical systems. They have own powerful programs for the computation of electromagnetic fields and their optical properties. This program is one of the best in the world. Thanks to the specialization of the team members (e.g. particle optics, vacuum physics and fine mechanics) it is possible to perform the theoretical and mechanical design up to the experimental realization. They are permanently working on the development of new simulation methods in electron and ion optical systems. They do simulations and design of nonstandard electron and ion optical systems, for the above mentioned firms and they closely cooperate with the universities in a broad.

Research areas – thematic research focus:
- Development of software for simulation of electron and ion optical systems
- Electron and ion optics

- Electron optical design and simulation
- Design of electron and ion optical instruments, including detection systems
- Simulation of the electron and ion source properties
- Ion mass spectroscopy

Excellence in the area:
- Electron and ion optical simulation of nonstandard systems
- Calculations of higher-order aberrations and current density profiles
- Space charge and stochastic Coulomb interactions
- Simulation of interaction of electrons with gas molecules
- Exploring the resolution limits of electron and ion optical systems due to aberrations, Coulomb interactions and diffraction

Group of Microscopy and Spectroscopy of Surfaces

Mission of the group:
The group developed unique method of Scanning Low Energy Electron Microscopy (SLEEM) with high lateral resolution (down to several nm) and very efficient detection system. This method is used in all Electron Microscopes in the world, now. Nowadays the group especially concentrates on the explanation of the contrast formation at low and very low energies (down to zero energy - mirror microscopy), quantitative measurement of the signals and comparison of the measured date with simulated ones. This work is excellent combination of the basic and applied research. A lot of cooperation were established, among the scientists dealing with the fundamental physics of the interaction of electrons with matter and scientists developing new materials. The group solved several projects supported by EU. The method found great applications in steel industry, industry of polymers, composites, surface coatings, etc.

Research areas – thematic research focus:
- Low energy scanning electron microscopy
- Auger electron spectroscopy and spectro-microscopy
- Diagnostic of micro- and nanostructured advanced materials and thin films
- Construction of ultrahigh vacuum systems for low energy electron experiments (e.g. Time off flight spectroscopy, the test of vortex beam technology)
- Analysis of phases in complex materials, e.g. steels
- Analysis of ultrathin tissue sections and free-standing films or 2D crystals

Excellence in the area:
- Study of contrast formation at low and very low energies in the scanning electron microscopy both in the reflection and transmission mode with lateral resolution of units of nm
- Design of new detection system for SLEEM (the use of multipole crossed electrostatic and magnetic fields)
- Detection of electrons emitted from surfaces or transmitted through films, including multichannel detection of angular and energy distribution of emitted electrons in SLEEM aiming at ultimate angular, energy and lateral resolution
- Interpretation of scanned electron beam micrographs formed by low energy electrons (surface topography) and Auger electron (material contrast from the surface)

Group of Microscopy and Microanalysis

Mission of the group:
The group is specialized to the use of new instrumentation methods of scanning electron microscopy (SEM) especially for material engineering. They cooperate with the universities and industry in Czech Republic and partially in a broad. They closely cooperate especially with the other Teams of the institute. Main mission of the group is, in the cooperation with other groups of the Team, the interpretation of the contrast formation in SEM.

Research areas – thematic research focus:
- High resolution scanning electron microscopy, complex specimen analyses
- Scanning transmission electron microscopy (STEM)
- Energy dispersive X-ray analysis (EDX)
- Determination of crystallographic orientation, defect studies, phase and grain boundary identification by means of Electron Backscatter Diffraction (EBSD)

Excellence in the area:
- Imaging of non-conductors (biological specimens) without conductive coating in standard vacuum high resolution SEM
- Study of the contrast formation by the energy analyses of reflected electrons from the specimen (both theoretically and experimentally)

Group of Microscopy for Biomedicine

Mission of the group:
The research of the group is focused on the quantitative transmission electron microscopy of biomedical specimens and on the investigation of scintillation materials based on single crystals of dioxides for the detectors of electrons in SEM. A technique for quantitative imaging of thin samples using detection of transmitted scattered electrons allows imaging of the structure of investigated objects at high resolution and simultaneous measurement of their local mass-thickness and mass, respectively. The team is concentrated on the study of electron interaction in solids, cathodoluminescence, and on the research of noise effects. The team activity includes the Monte Carlo simulation of interaction processes and related optical effects. The results of the measurement are compared with the values predicted by the theory and obtained by a computer simulation. There is established long term cooperation with CRYTUR, Turnov on the development new scintillation materials. Had of the group, Dr. Krzyžánek, returned to the institute after long term stay at the University in Munster, Germany.

Research areas – thematic research focus:
- Scanning transmission electron microscopy of biological specimen
- Cryo-preparation techniques for electron microscopy
- Novel techniques in correlative microscopy
- Monte Carlo simulation of the interaction of electrons with material
- Theoretical and experimental study of cathodoluminiscence
- Efficiency and kinetics of cathodoluminescence using time-resolved spectroscopy in a large temperature range

Excellence in the area:

- Development of hardware, software and specific sample preparation technique of biomedical and soft matter samples for quantitative imaging using annular dark-field mode in STEM
- Detection of very low signals in STEM for quantitative imaging, mass measurement of macromolecular complexes
- Study of very weak cathodoluminescence using Time Correlated Single Photon Counting (TCSPC)

Group of Environmental Electron Microscopy

Mission of the group:
The group is deeply focused on theoretical and experimental research in the field of signal detection, new methods and instrumentation for the study of various types of samples in high pressure conditions of Environmental SEM (ESEM). They led this topic in Czech Republic. The tradition was started over twenty years ago when the first ESEM in Czech Republic was designed in cooperation with the TESCAN Company. The group is excellent in the understanding of the influence of electron-liquid and electron-gas interactions on signal detection and imaging in ESEM. They developed and patented new detection systems for ESEM. The group deals with the theoretical and experimental research of electron-gas interactions in ESEM (Monte Carlo simulations and theoretical models of electron-gas interactions and signal amplification, electron beam scattering in gas environment, electron-gas ionisation and excitation phenomena, charge recombination processes in gas, Monte Carlo simulations of electron-water interactions and study of electron energy losses in thin water layer).

Research areas – thematic research focus:

- Environmental scanning electron microscopy (ESEM)
- Study of sensitive samples of various natures (electrically non-conductive, wet, biological, living cells and animals)
- Morphological, chemical and structural changes of samples studied in conditions of dynamical in-situ experiments in ESEM

Excellence in the area:

- Design and manufacturing of scintillation single crystal detectors of backscattered and secondary electrons working in high pressure environment
- Design and manufacturing of ionisation detectors for ESEM
- Gas flow computations in ESEM and detection systems for ESEM (design of optimum geometry of differentially pumped chambers and ESEM equipment as detectors, hydration systems, etc.)
- Understanding of mechanisms of generation and multiplying of signal electrons in an environment of high pressure gas and simulation of these phenomena
- Methods for observation of stem cells and other wet biological samples in their native state as well as of live animals in ESEM

1.4 Staff size and full time equivalents age distribution

The Team No.1 (Electron microscopy) is the largest in the Institute.
The sum of the full time equivalents as of December 31, 2014
Technical workers: 6.41 (15 persons)

Researchers 15.86 (27 persons)

Age structure of the Team 1 [under the Institute Report]

Age	<25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	>70
number	2	5	7	4	1	0	1	2	1	2	2

Result: More than 1/2 employees involved in research are younger than 35 years and represent the pool for future group leaders and experts. More than 1/4 employees involved in research are in the productive age (35-65) with deep experiences in their fields.
The rest of employees consist mainly of very important experts and emeritus scientists with broad experiences and skills that are dissipated to younger colleagues.

2. STRENGTHS AND OPPORTUNITIES

2.1 Timeliness of research topics

The Team of Electron microscopy deals with modern topics combining theoretical studies with numerical modelling and experimental studies with a direct very high impact on industrial applications. Most of the Team research topics are very exacting and perspective both from the theoretical and application point of view. They represent top research areas in the current physics, engineering, medicine, biology, and material sciences. The general research topics are relatively stable. Research capacities are focused at one location which is considered advantageous for efficient cooperation across teams at multidisciplinary projects.

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

Strong point: Good collaboration inside the institute and with Czech universities.
The research Department No 1 collaborate with another departments and teams of the Institute, the collaboration among them depends on the current needs and possibilities, e.g., utilization of the special instruments, joint participation on the projects etc. Cooperation of the Team with other research subjects and universities both in the Czech Republic and around the world is **very intensive and fruitful**.

2.4 Position of the institute within the Czech scientific community and its international position

The Team of Electron Microscopy is leading in development of this type of high-tech instruments. At the moment the Team activities are **balanced** between the fundamental research and applied research together with development. Position of the Team as well as of the Institute within the Czech scientific community in the aforementioned research areas in the top level and many of the research results obtained are **original and essential on an international scale**.

2.5 The overall capacity of staff

The Team has 27 researchers, 9 Ph.D. students, and 15 technical workers. Stable number of researchers with increasing FTE - continually increasing number of employees during the evaluation period is obvious from materials provided. Details: technical workers - 6.41 (15 persons), researchers - 15.86 (27 persons). There is relatively large number of technical workers in the Team, which is probably because a lot of complicated experimental set ups is performed.

2.6 Reasonability of the structure of the team

The structure of the Team is based on historical development. This structure is **reasonable**; it is based on the heterogeneity of the main individual research topics.

2.7 Comments on the age structure

Very good age structure of the Team with increasing number of research members including young researchers makes a promising background for the future development of the Team.

2.8 Frequency and quality of publications

Publication activity of the Team is above average per researcher in comparison with other CAS institutes of the similar orientation. For many years the ISI was mainly focused on development of high-tech instruments.

Team of Electron Microscopy – results during the period 2010 - 2015

	Team of Electron Microscopy
Papers in journals with IF	76
Papers in other journals	11
Scientific books	0
Papers at conferences	136
Patents	1
Applied results	20
Number of scientists	12,04
Number of other workers in department	6,84

During the 2010-2014 period, there were published papers in journals with IF (76 in total), papers in other journals (11 pieces), and papers at conferences (136). There was 1 patent and 20 applied result. In the Evaluation Phase I, 10 selected publications were classified as world-leading and 40 as internationally excellent.
However it seems that the Institute researchers prefer quality to quantity because averaged impact factor of ISI papers published in 2010-2014 is 3.1 which is well above the CAS average in applied physics (2.1, data taken from http://www.lib.cas.cz/arl).

2.9 Patents and role in contractual work

During the 2010-2014 period there is 1 patent and there is **considerable** contract research work. Contractual work is a source of **significant** incomes of the Team. The role of the Institute on contractual work is generally not related to patents but in the solution of practical problems. The

amount of time and resources coming from contractual research is limited with respect of the other source of budget.
There are no weaknesses and threats related to patents.

3. WEAKNESS AND THREATS

3.1 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The Department of the EM acquire funding from contract research (industrial partners), from the Czech Academy of Sciences, the Czech Science Foundation, regional science support (South Moravia) and EU projects. The funding sources are diverse. The situation in this department is similar to the whole Institute with **nearly full project funding**. A key impulse that moved the whole institute towards project funding was participation within the EU project from structural funds **ALISI**. It helped the institute to build new laboratories, purchase new, state-of-the-art equipment and hire more people.

Activities of the Deartment No.1 concerning projects

	2010	2011	2012	2013	2014
Projects	9	8	7	10	8
Project budget (kEUR)	401	336	540	561	576
Contractual research (kEUR)	16	9	28	27	29

The Team as well as the whole Institute would prefer a larger part of the funding provided directly by the CAS, without competition. The evaluation commission understands that it would be much more comfortable for the institute to have a larger amount of non-competitive funding. It can support the stability of the research department from the point of view of staff and research directions.
The evaluation commission judges that the distribution of the income of the institute among the three main sources (direct funding by the CAS, industrial contract work, grants obtained from agencies in a competitive way) is well balanced. A threat, to which most research teams in western and middle Europe are confronted with, including the Institute of Scientific Instruments, is the tendency for reduction of the funding possibilities on the national level and thus the necessity to be more successful in projects with EU funding or international funding. The institute is fully aware of this necessity and has succeeded in participating in large EU projects, with considerable funding for acquiring research equipment. Clearly, continued efforts in trying to participate in EU projects are necessary.

3.2 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

The staff is only partially international. The department includes 2 foreign researchers. It is not easy to attract high-quality researchers (and their families) from abroad to a place (Brno) where the main spoken language is Czech, where it is difficult to educate children in their native foreign language, and where the salaries follow the national level to keep the acceptable social balance between foreigners and Czechs at the corresponding level of work productivity. Fortunately the representatives of South Moravian Region are getting active in targeted help for high qualified foreigners and make this region more attractive for them to come and also stay longer.

4. RECOMMENDATIONS

4.1 Re-organisation of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

At the moment we do not recommend some type of re-organisation of the internal structure of the Team No 1. The Team must be prepared to solve new research topics in future. For these purposes it is desirable to looking for other adequate personal and financial sources in the future.

4.2 Internal programs to stimulate actions to enforce strengths and to reduce weaknesses

Within the Institute they have various programs to enforce strengths and to reduce weaknesses and emphasis on the contributions in high quality journals. They use the internal programs to incentive and to stimulate a conversion of results from conference contributions into regular journal articles. Focus on strengthening of international collaboration. The teams are under the supervision The Director and The Council.

4.3 Identification of new research topics

The Institute (ISI) research plan (for 2015–2019) consists of research plans of all departments described in details. The main goal is to utilize researches' intellectual potential and up-to-date equipment and enhance existing methods of investigation of nano-world, micro world and macro world in the relevant areas of physics, biology, medicine and engineering. There does not seem a direct need to search for another new research topics. These come spontaneously.
The most important trends within the group of Electron Microscopy are as follows:

- Crystallographic imaging using low energy scanning electron microscopy (SEM)
- New methods of low voltage environmental SEM and quantitative SEM imaging
- Correction of aberrations in parts of electron source, time-of-flight and in-lens detectors using our original methods of electron optical calculations
- Low energy scanning transmission electron microscopy in ultra-high vacuum with energy loss spectroscopy (cooperation in the frame of EU project SIMDALEE2)
- Generation of vortex electron beams, examination of their interaction with solid targets and their utilization in imaging with electron beams
- Creation of electron sources based on nanostructures such as carbon nanotubes (in cooperation with the University of York, UK)

5. DETAILED EVALUATION

5.1 Declaration on the quality of the results and share in their acquisition

Characterisation of the main research activities (experiments, theoretical areas)

The main research activities of the Team have very complex character and they include both very exacting theoretical approaches and **sophisticated** experimental research. Main results can be shortly divided into five groups, reflecting the division of the Team into five groups.

Relevance in the national and international context

Research activities of the Team have undoubtedly very important relevance not only in the national, but also in international context. Results were received within the frame of Czech research projects, international projects, and international cooperation.
The Team is unique with respect to complete expertise in SEM, Transmission SEM and ESEM. It is successful in many national project applications.

Overall quality of publication

Scientific outputs of the Team researchers have generally good quality. The majority of evaluated publications belongs to internationally (14) and nationally recognized outputs (20). Among world-leading publications there is 1 paper. Some papers are in quartiles 1-2 by AIS of journals (6 + 5). These facts were confirmed in the Evaluation Phase I. Also intensity of citations of these publications is on average level.

Specification of the main achievements

- Simulation of Coulomb interactions in electron and ion optical systems including the region in the vicinity of emitting surfaces and their influence on beam properties and resolution of the system.
- Calculation of higher-order aberrations of electron and ion optical systems, calculation of current density beam profiles.
- Simulation of nonstandard electron and ion optical systems (electron mirror, extraction optics of Time-of-Flight detectors, Wien Filter with permanent magnets, general 3D optical systems), correctors and misalignment aberrations.
- Study of transmissivity of ultrathin free standing foils at very low energies in scanning electron microscope with a high contrast and a high lateral resolution in the nanoscale.
- Characterisation of crystal orientation with a high lateral resolution from the reflectivity of electrons at impact electron energies between 50 eV and 1 eV. The information is proportional to the local density of electron states.
- Applications of low energy SEM in nanotechnology.
- Development of new highly sensitive method for the determination of crystallographic orientation of grains from maximum anisotropy of reflected electrons. Tiny changes in the lattice constant caused by local deformations are made visible. The method has a very high sensitivity to the local 3D inner potential.
- A method for quantitative measurements of dopant level in semiconductors using the secondary electron yield at optimum primary beam energy.
- An overview about the development of the scanning low energy electron microscopy.
- An automatic method for the imaging of uncoated and nonconductive specimens by fine-tuning the primary beam energy so that the number of incoming and outgoing electrons from the specimen is equal.
- Mini scanning low energy electron microscope with the total length of 10 cm was designed and tested for the in situ observation of surfaces by Auger electrons and by low energy electrons. Six channel detectors were designed for the collection of Auger and low energy electrons.

- First experiments showing the diffraction contrast in SEM and surface crystal orientation of clean Si were performed.
- Applied result Detector of transmitted very low energy electrons for the ultra-high vacuum scanning low energy electron microscope, functional module
- Mastering of original methods of biological specimen imaging without conductive coating. This method reveals the real nanostructure and microstructure of the studied sample without coating artefacts. Recently they have focused on natural photonic crystals with interesting optical properties present in butterfly wings.
- Imaging of doped structures using SEM to reveal the distribution of dopants in semiconductor devices to improve the control of the manufacturing process and reduce the production costs.
- Quantitative electron microscopy: Characterisation of biological, biomedical and soft-matter samples using SEM and TEM techniques. The preparation and observation of hydrated samples by SEM, cryo-SEM, FIB-SEM and correlative microscopy.
- Mastering of original methods of biological specimen imaging without conductive coating. This method reveals the real nanostructure and microstructure of the studied sample without coating artefacts. Recently we have focused on natural photonic crystals with interesting optical properties present in butterfly wings.
- Imaging of doped structures using SEM to reveal the distribution of dopants in semiconductor devices to improve the control of the manufacturing process and reduce the production costs.
- The morphological study of undifferentiated human embryonic stem cells in different state of preparation was realized using ESEM and SEM.
- New system of pressure-limiting apertures for scintillation secondary electron detector was introduced.
-

Specification of the contributions of the team to publications

Typical for the majority of outputs is a high portion of work done only by members of the department including experiments, calculations, theoretical background and interpretation.

5.2 Declaration on the involvement of students in research

Involvement of students (doctoral, undergraduate) into research

Students are involved into the research of the institute within the frame of their bachelor, master and doctoral studies.
ISI CAS is not authorized to award academic titles (BSc, MSc, PhD) as such. It is however accredited as a scientific research workplace for the students of Masaryk University and Brno University of Technology. Experienced researchers at the Team serve as students‘ PhD, MSc and BSc supervisors, approved by scientific boards at the respective universities.
- A supervised student’s entire scientific research is performed at the ISI, where the students spend most of their time.
- ISI strives to create above-standard conditions for the students:
- Paid work contracts as a bonus to the scholarship that the student gets at the university
- Participation at conferences
- Engagement in research projects
- Fellowships abroad
- Participation in Marie Curie Actions (PEOPLE).

Involvement of students (doctoral, undergraduate) into research (Team No 1)

	2010	2011	2012	2013	2014
Scientists	11	13	13	14	18
Ph.D. students	5	8	10	8	9
MSc. students	1	0	1	4	4

Particular contributions of students to research

Students generally work on topics of their supervisors. Students are significant contributors to all scientific outputs of the Team. In the framework of various national projects, many doctoral and undergraduate students are introduced into the joint research team. They can do very useful scientific work and help their advisors in their research tasks. Collaboration with doctoral and undergraduate students often results in publications co-authored by the students. This kind of collaboration with Universities is very beneficial for the both contracting parties.

Number of defended PhD students in relation to students involved (success rate)

Institute in collaboration with Universities has participated on Ph.D. students education. Leading researchers are often supervisors of Ph.D. theses. PhD training has served the Institute as a hiring tool; Institute systematically tries to increase jobs openings for young scientists. In the period 2012-2012 in total 26 doctoral theses were successfully defended. For the Team No 1 there were 7 successfully defended. Success rate was **100 %**.

Supervision of students (Team No 1)

type of study	No of supervisors	No of consultants or co-supervisors	Theses defended in 2012-2014
Bachelor	3	0	3
Master	3	0	2
Doctoral (Ph.D.)	7	0	7

Employment of former Ph.D. students (career options)

Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students, including female students, are now members of the research department. The former Ph.D. students can continue their contract as so-called “post-docs”. The possibility to open new positions for postdocs within the teams of the department is given by the **successes in grants and projects** which provide funding for them.

5.3 Declaration on societal relevance

Societal relevance in technical sciences primarily means a contribution to the competitiveness of the national economy through applied research in cooperation with industrial partners. In technical sciences a significant part of motivation comes from the application sector. The link to practice is in technical branch of research inevitable and deeply incorporated in any research strategy. In the field of

instruments and instrumentation research the inspiration in research is a mixture of impulses coming from industry and from basic research. High-end instrumentation represents nowadays a key and determining tool in the process of understanding the universe.

Impacts of the results and other activities on economy

Team has established itself as a regional technology center. Long-term, focused and in-depth research in a series of selected research topics has helped department to open a number of **fruitful collaborations** with a large number of industrial partners in Czech Republic and abroad.

Impacts of the results and other activities on education

The department members contribute also to teaching on various levels. Researchers participate actively in educational bachelor, master and doctoral programs mainly at Masaryk University and Brno University of Technology. The involvement of the department in student supervision is also very good.

Impacts of the results and other activities on culture

The research of the department respond to actual needs of society in many areas, cooperation with industry, access to microscopic methods and equipment speeds up development and increases competitiveness of Czech industry, analysis and cooperation on development of electron optical devices have an **impact** on local industry with high added value.
There is certainly a contribution to the economy by the activities of the Team. The Team has a **broad collaboration** with the industry and participate on solving of manufacturing problems of industrial partners and research institutes and universities within the frame of contractual research.
Research activities and their results have very **strong impact** on the Institute economy – both institutional and grant parts of the budget depend on the quantity and quality of the outputs. High level of the scientific work, experience of the researchers and many unique experimental instruments offer very good opportunities for many students.
During the 2010-2014 period, there were the following awards given:

- Dr. Ilona Müllerová - The Award of the Czechoslovak Microscopic Society for livelong contribution to microscopy The Czech Head for long-term systematic research in electron microscopy,
- Dr. Zuzana Pokorná Award of Czechoslovak society for the best PhD. thesis, in which the microscopic techniques were used,
- Ms. Sarka Mikmekova – FEI Scholarship.

Outputs providing information relevant for public policy decisions in all fields of life

See: Impacts of the results and other activities on economy

Services for research (libraries, data bases, collections,..)

The institute has a large library which can also be used by external researchers. There are various types of services for research.

Popularisation and similar activities

The Team participates in activities of popularisation of science. There are contributions to TV and radio programmes and it produces press releases: Czech TV (19), Czech Radio (8), Articles in newspapers and journals (12), Public lectures (7), Exhibitions (9), each year: Week of Science and Technology of the CAS, Visitor‘s Days of the ISI.
The evaluation commission judges the effort of the institute and particular teams in science popularisation as very good.

5.4 Declaration on the position in the international and national context

There is a **unique** expertise developed with respect to its scientific impact opens many cooperation opportunities (joint grant applications). The town of Brno is significant in electron microscopy in the region, three companies producing microscopes are situated in Brno, more than 30% of world Electron microscope production comes from Brno).

Comparison of the position, recognition, outputs and impacts with leading and international teams

Position of the Team in both national and international scientific community is very important. Research activities of the department have undoubtedly very important relevance not only in the national, but also in international context. The research work at the Team is at the excellent level. The Team is leading in development of high-tech parts of the instruments. At the moment the Team activities are balanced between the fundamental research and applied research together with development. Position of the Team within the Czech scientific community in the aforementioned research areas in the top level and many of the research results obtained are original and essential on an international scale. Position of the Team in the international scientific community is strong and very important.

Role and position in international collaboration

The department is very well **integrated** into international cooperation, especially thanks to participation in the framework of **4 EU projects**: **FP7-PEOPLE-2013** Interaction with Matter and Analysis of Low Energy Electrons, **FP7-NMP 200613** Combined SIMS-SFM instrument for the 3-dimensional chemical analysis of nanostructures, **FP6-NEST-2004-ADV-28326** Obtaining atomically resolved structural information on individual biomolecules using electron holography, and **ENIAC JU EEMI450** European 450mm equipment demo line.

Breadth/completeness of the research activities compared to world leading teams of comparable size

The department should be compared to the partners it cooperates, like Technical University Vienna, University of Toyama, Japan, University of Münster, University of York, UK, University of Amiens,

France, ETH Zurich, Cambridge University, UK, and others. Seen as a team doing research in technical sciences the publication activity is not the only factor to compare performance, it has to be seen through the **whole portfolio of research outputs** including applied research, development of instrumentation, knowledge and technology transfer etc. From this point of view the outputs are good.

Ability to attract foreign researchers at different levels

The Department Electron Microscopy includes **2 foreign members** which is **a** good number for the standards of the Institute (and Brno as well). This has been supported also by a European project FP7-PEOPLE-2013 (2014-2018) SIMDALEE2.

Possible missing research directions

There are no missing research directions.

Position of the team in the national context

Position of the Team in both national and international scientific community is very important. The groups belong to leading Team at the national level with established collaborations with several Czech teams mainly at universities. The number of research projects funded by grant agencies confirms this statement.

5.5 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience

The age structure of the department is of a very good distribution including students, young researchers, post docs, research fellows and senior researchers with the best qualifications reachable in the Czech Republic, which is further improved by a direct collaboration with foreign institutes. Nevertheless, the department with **2 foreign** researchers supported by international project represent a good starting point.
The Institute provides financial incentives to research teams successful in solicitation research funding or contractual research.

Attraction of research programmes for young people

The research programmes seem very attractive for young people. The research groups use modern methods and unique facilities.

Funding (structure of the resources and its comparison with the outputs, grants and projects activity

The structure of funds is **balanced** with a good contribution from contractual research (about 5%) and national resources, primarily form projects with only a little portion of institutional funding. A key

impulse that moved the whole institute towards project funding was participation within the EU project from structural funds **ALISI**. It helped the institute to build new laboratories, purchase new, state-of-the-art equipment and hire more people.
The Team is already well integrated in EU projects, participating in **4 international** projects represents a very good number and this effort should continue.

Effectiveness of research (based on comparing size of groups, funding and output)

The output of the Team in number of publications, scientific instruments, and methodologies is **very good**.

Organisational structure, recruitment methods, career system, incentives for females, young researchers, international researchers

Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students, including female students, are now members of the research department. The former Ph.D. students can continue their contract as so-called "post-docs". The possibility to open new positions for postdocs within the teams of the department is given by the **successes in grants and projects** which provide funding for them.

5.6 Declaration on the strategy and plans for the future

Relevance of the out lined strategy and research plans

Detailed research plan of the Institute for 2015-2019 is prepared in **great details**. Plan of the Institute is especially based on its human resources and budget. The Institute will continue in participation of existing research Departments. The basic policies of the Institute will be focused mainly on institutional support of grant applications, efficient use of existing experimental equipment, and support for the rising interdisciplinary research, openness towards commercialization of research results.

Adequacy of available means and human resources to achieve these plans

The capabilities of the existing research department are very good. Supplementary recruitment of researchers will be necessary. Obtaining supplementary funding will also be necessary.
The Institute wants to maintain the general organisational structure of the ISI departments, but to be flexible enough to support new scientific directions for strong individuals or projects, so that new groups can be formed. Also they want to follow the healthy common sense and keep a friendly and cooperative atmosphere at ISI so that everybody can enjoy the creative work.

Missing issues in the strategy

There are no missing issues, provided that the Team is serious about setting up strategic co-operations with foreign research teams with the objective of acquiring funding from EU sources.

EVALUATION OF THE INSTITUTE OF SCIENTIFIC INSTRUMENTS

Dept. of New Technologies

This report refers to the Evaluation of the Institute Scientific Instruments (ISI) – Department of New Technologies - of the Academy of Sciences of the Czech Republic, 2010-2014, and is written according the to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS. This evaluation is based on the materials provided from the Institute of Scientific Instruments and from their particular departments, from the web pages [www.isibrno.cz], from particular presentations, and last but not least from discussions with researchers and management of the Institute (all within the "on site visit" on October 19, 2015).

1. INTRODUCTION

There are 3 groups within the department **New Technologies**
1. The Group of Thin Layers
2. The Group of Electron Beam Technology
3. The Group of Electron Lithography

1.1 Location of the institute and its dept., labs. & sub units.

Laboratories and the other facilities of this department are in the main building of the Institute (Královopolská 147, 612 64 Brno).

1.2 Brief history of the institute (department)

The Institute of Scientific Instruments (ISI) was established in 1957 (from the Developmental Workshops of the Czechoslovak Academy of Sciences in Brno) as an institution providing instrumental equipment for other institutes of the Academy of Sciences in many areas. The Department of New Technologies puts together groups that constitute the technology background of the Institute and do methodology and technology oriented research.
[Based on materials provided and materials from www.isibrno.cz]

1.3 Mission and research topics

Involvement of the department in the Strategy of the CAS AV21
The research programme "Diagnostic Methods and Techniques" of the new Strategy AV21 includes several research topics, or sub-programmes. The Department of New Technologies is involved in one of them, called "Special technologies for extremely precise and technically advanced applications", which is coordinated by Jaroslav Sobota, head of the Department of Special Technologies, ISI.

1. The Group of Thin Layers

Mission of the team:
The group of **Thin Layers** is dealing with **r.f. magnetron sputtering** of thin films. The group started development of **multilayer systems** consisting of a large number of double layers of **nanometer** thickness for use in the **x-ray optics**. The collaboration with coating centres in Czech Republic in the field of the study of sputtered layers of carbon and carbon nitride led to the preparation of nanostrucured multilayers and nanocomposite carbon based systems. Now they are the **only laboratory** in the Czech Republic offering **dynamic impact wear tests** for coating centres which produce hard coating. The repeatability of the bilayer thickness of the Mo/Si multilayer is better than 0,1 nm.

Research areas – thematic research focus:
- deposition of thin films by magnetron sputtering and dynamic impact testing, microfluidic field-flow fractionation
- study of self-organized growth of nanocrystals
- study of mechanisms of dynamic impact wear of films / substrate systems
- study of thermal diffusion of macromolecules, nano- and microparticles by microthermal field-flow fractionation

Excellence in the area:
- multilayer X-ray and EUV optics
- creation and characterization of nanolayers used in soft X-ray lasers
- dynamic impact testing of thin films
- deposition of thermally stable nanostructured DLC coatings

2. Group of of Electron Beam Technology

Mission of the team:
The group of **of Electron Beam Technology** is dealing with both the development of technologies and the design of technological equipment representing the basis for the building of **electron optical devices** operating in vacuum or ultrahigh vacuum conditions. These technologies include **electron beam welding** and **micromachining, vacuum brazing**, pulsed laser welding, the development and manufacturing of vacuum electric feedthroughs, etc.
A new method of joining metals with brittle non-metal materials by brazing using ductile active brazing solders and the method of electron beam welding of metal materials with different physical properties have been developed. A function model of a desktop electron beam welding machine intended for welding of instrument parts has been realized.

Research areas – thematic research focus:
- electron beam welding
- vacuum brazing and vacuum feedthroughs
- special electronics
- brazing of metals with brittle non-metallic materials using pliable active filler metals
- study of homogenous and heterogeneous joints of various metals

Excellence in the area:

- electron beam welding of dissimilar metals,
- development of electron beam welders including high voltage power supplies

3. The Group of Electron Lithography

Mission of the team:
The group **of Electron Lithography** is dealing with the research in the field of microlithographic technology using an e-beam lithograph. Its activity concentrates on large-size micro-structure diffractive optical elements for laser-beam forming, sub-micron **diffractive holography structures** for industrial holography applications, and thin-film metallic and dielectric structures on silicon substrates for biosensors and conductive chemical sensors. This research necessarily includes the dealing with off-line and on-line software enabling exposition of large-volume data, proximity effect, dimension distortion of deflection field (caused by imperfection of optical deflection system and by temperature drift), and modelling and simulation of generated structures that simplify the design cycle and enable parameter optimization.

Research areas – thematic research focus:
- e-Beam Lithography for Nanotechnology
- e-Beam writing system with rectangular shaped beam working at 15 kV. Resolution 100 nm. Electron scattering during resist exposure.
- industrial Holography Using E-Beam Lithography
- large-size micro-structure diffractive optical elements for laser-beam forming and sub-micron diffractive holography structures for industrial holography applications.
- microlithography technology
- thin-film metallic and dielectric structures on silicon substrates for biosensors and conductive chemical sensors.
- nanolithography
- structures with resolution below 100 nm prepared by scratching AFM lithography.

Excellence in the area:
- variable-shaped e-beam writer
- Fourier and Fresnel structures, diffractive optically variable image devices (DOVIDs)
- micro-sensors and calibration specimens

1.4 Staff size and full time equivalents age distribution

The department No 2 (New Technologies) is relatively small. The sum of the full time equivalents (FTE) as of December 31, 2014,
technical workers: 6.50 (7 persons)
researchers 7.60 (11 persons)

Age structure od the Department 2 [under the Institute Report]

Age	<25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	>70
number	0	1	3	2	0	3	0	0	1	1	0

Result: more than 80% of scientists of the department of NT have age between 25 and 50 years and about one-fourth of staff are students.

2. STRENGTHS AND OPPORTUNITIES

2.1 Timeliness of research topics

The research topics seem all **well-chosen**. The department deals with modern topics combining theoretical studies with numerical modelling and experimental studies with a direct impact on industrial applications. Most of the institute research topics are very exacting and perspective both from the theoretical and application point of view. They represent **top research** areas in the current physics, engineering, medicine, and material sciences. The general research topics are relatively stable.

2.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The funding sources are **diverse**. The situation in this department is similar to the whole Institute. The funding from The Czech Academy of Sciences is circa 25 %. The main portion of money is from various grant projects and from collaborative research. This diversity can be also seen as a **threat**. On the other hand it is a success that the department **succeeds** in numerous project applications and **contract** research projects.
The evaluation commission judges that the distribution of the income of the institute among the three main sources (direct funding by the Academy of Sciences, industrial contract work, grants obtained from agencies in a competitive way) is well balanced.

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

The research department No 2 collaborates with another departments and teams of the Institute, the collaboration among them depends on the current needs and possibilities, e.g., utilization of the special instruments, joint participation on the projects etc. Cooperation of the Institute with other research subjects and universities both in the Czech Republic and around the world is **very intensive and fruitful**. Due to its multidisciplinary technology orientation that is beneficial for other researchers and companies, the portfolio of collaborators in the Czech Republic as well as abroad is wide and has a potential to grow.

2.4 Position of the institute within the Czech scientific community and its international position

The Department of New Technologies is leading in development of highly sophisticated technologies. Position of the department as well as Institute within the Czech scientific community in the aforementioned research areas on the top level and many of the research results obtained are **original and essential** on an international scale. A rich history of collaborative research of the department directs predominantly towards companies in the Czech Republic. Large amount of contract research confirms the position of the department.

2.5 The overall capacity of staff

The composition of the department (11 researchers, 5 Ph.D. students, and 7 technical workers) is well balanced and arranged for the research and projects the department is involved in. Stable number of researchers with increasing FTE - continually increasing number of employees during the evaluation period is obvious from materials provided.

2.6 Comments on the age structure

Age structure of all Institute employees is summarized in the table above (chapter 1.4). More than 80% of scientists of the department of NT have age between 25 and 50 years and about one-fourth of staff are students. Very good age structure of the scientific department with increasing number of research members including young researchers makes a **promising background** for the future development of the Group.

2.7 Frequency and quality of publications

During the 2010-2014 period, there were published papers in journals with IF (19 in total), papers in other journals (10 pieces), and papers at conferences (51). There were 67 applied results. In the Evaluation Phase I, one selected publication was classified as world-leading, 4 as internationally excellent, and 6 as internationally recognized.
Publication activity of the department is **adequate** to the field of "Instruments and instrumentation research", slightly lower in comparison with other CAS teams; the department outputs are diverse, publications represent only part of them.

Department of New Technologies – results during the period 2010 - 2015

	Department of New Technologies
Papers in journals with IF	19
Papers in other journals	10
Scientific books	1
Papers at conferences	51
Patents	0
Applied results	67
Number of scientists	7.05
Number of other workers in department	6.84

2.8 Patents and role in contractual work

During the 2010-2014 period no patents was supplied by the department but there is **significant contract research** (242 kEUR). Contractual research is a source of significant incomes. The role of the Institute on contractual work is generally not related to patents but in the solution of practical problems. The amount of time and resources coming from contractual research is limited with respect of the other source of budget.

3. WEAKNESSES AND THREATS

3.1 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The department is **predominantly project funded.** It is a product of the research environment in the Czech Republic with a large portion of purpose (project funding).
The Comment of the Commission: The department as well as the whole Institute would prefer a larger part of the funding provided directly by the Academy of Sciences, without competition. The evaluation commission understands that it would be much more comfortable for the institute to have a larger amount of non-competitive funding. It can support the stability of the research department from the point of view of staff and research directions.
A threat, to which most research teams in western and middle Europe are confronted with, including the Institute of Scientific Instruments, is the tendency for reduction of the funding possibilities on the national level and thus the necessity to be more successful in projects with EU funding or international funding. The institute is fully aware of this necessity and has succeeded in participating in large EU projects, with considerable funding for acquiring research equipment. Clearly, continued efforts in trying to participate in EU projects are necessary.

3.2 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

There is a **good collaboration** inside the institute and with Czech universities. Higher intensity of international collaboration would be useful.
The research department No 2 collaborates with another departments and teams of the Institute, Cooperation with other research subjects abroad is mostly not in the sense that these collaborations benefit from EU or international research grants.

4. RECOMMENDATIONS

4.1 Re-organization of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

At the moment we **do not recommend** some type of re-organization of the internal structure of the department No 2. It must be prepared to solve new research topics in future. For these purposes it is desirable to looking for other adequate personal and financial sources in the future.

4.2 Internal programs to stimulate actions to enforce strengths and to reduce weaknesses

Within the Institute they have various programs to enforce strengths and to reduce weaknesses. Emphasis is on contributions in high quality journals. There are internal programs and incentives to stimulate a conversion of results from conference contributions into regular journal articles. Focus on strengthening of international collaboration. The teams are under the supervision The Director and The Council.

4.3 Identification of new research topics

The research plan of the whole institute (for 2015–2019) sets the main goal to utilize researches' intellectual potential and up-to-date equipment and enhance existing methods of investigation of nanoworld, microworld and macroworld in the relevant areas of physics, biology, medicine and

engineering. There does not seem a direct need to search for another new research topics. These come spontaneously. Relevance of the plans is limited by funded grants and projects.
The **most important trends** within the department of New Technologies are as follows:

- advancement in magnetron sputtering deposition of multiple interfaces with subnanometre roughness and thickness repeatability in tenths of nanometres
- impact testing of coating–substrate system (cooperation with external partners)
- further development of methods of electron beam welding and vacuum soldering
- optimization of electron guns for e-beam welding (cooperation with Focus GmbH)
- optimization of e-beam writing methods for the purposes of electron and optical microscopy calibration, manufacturing of photolitographic masks, diffraction gratings, plasmonic and planar waveguiding structures
- support of other ISI teams demanding new technologies

5. DETAILED EVALUATION

5.1 Declaration on the quality of the results and share in their acquisition

Characterization of the main research activities (experiments, theoretical areas)

The main research activities of the department have **very complex** character and they include both very exacting theoretical approaches and sophisticated experimental research. Main results can be shortly divided into three groups, reflecting the division of the department into three groups.

Relevance in the national and international context

Research activities of the Institute and particular Teams have undoubtedly very important relevance not only in the national, but also in international context. Results were received within the frame of Czech research projects, international projects, and international cooperation.
The department is **unique** with respect to complete expertise in sputtering and electron lithography. It is successful in many national project applications.

Overall quality of publications

Scientific outputs of the department researchers have generally good **quality**. The majority of evaluated publications belongs to internationally (11) and nationally recognized outputs (4). Among world-leading publications there is 1 paper. Two papers are published in top decile (1*) and quartiles 1-2 by AIS of journals (1 + 5). These facts were confirmed in the Evaluation Phase I. Also intensity of citations of these publications is on average level.

Specification of the main achievements

Thanks to a diversity (three teams within this department) of research topics over the specified period the main achievements can be presented as the results of the numerous research projects in a following short overview:

- optimization of deposition parameters and subsequent deposition of advanced multilayer Sc/Si, Mo/Si a C/Si XUV mirrors with low interface roughness not surpassing 0.3 nm
- design and deposition of a wide range of precise Mo/Si, Sc/Si, Ni/C and C/Si multilayer samples having both different material compositions and different periodicities to perform SThM conductivity mode calibration, resolution estimation and uncertainty components evaluation.
- preparing of precise structures – cobalt or germanium nanocrystals embedded in amorphous silicon oxide layer
- testing of five variations of DLC coatings using an in-house developed impact tester; evaluation of an influence of humidity on the tribological behavior of the carbon–based coatings and their impact resistance.
- plasma etching experiments of solar cells using a mixture of argon and hydrogen to substitute wet etching by hydrofluoric acid; increasing of solar cell efficiency by more than 2%, development of colored solar cells without a loss of their efficiency.
- preparation of radiofrequency magnetron sputtered tungsten coatings with low roughness on sapphire substrates and measurement of FF absorptivity
- development of modified knife–edge method for current density distribution measurements in e–beam writers and coincidental imaging system with electron optics
- development of glass sealed vacuum and pressure electrical feedthroughs for vacuum instruments, technology equipment, nuclear research, aviation etc.
- development of vacuum tight joints of metal parts made of steel, stainless steel, copper alloys, titanium alloys, zirconium alloys, high temperature resistant superalloys like Inconel etc.
- development and design of a micro–electron–beam machine MEBW–60/2 which was finished in 2007 and is now produced by the German company FOCUS GmbH under ISI's license
- finishing and building of a new version of the electron gun ET–60/2 V1.3, which is the electron generator of the MEBW
- development and design of a sputtering system for deposition of BDLC coatings
- equipped by mass flow controllers enabling precise measurement of gas flow and equipped with a number of special features; testing deposition of a number of modified DLC coatings to find a proper combination of properties suitable for electrochemical sensors and biosensors
- development of a precise 100 kV high voltage supply intended for electron microscopy and/or lithography with field emission electron guns; prototype was extensively tested for more than one year; stability achieved better than 2.5 ppm at 100 kV over a 24-hour period
- development of a special low capacitance measurement device for experimental study of the near–field heat transfer; the resolution is about 10 fF.

Specification of the contributions of the team to publications

Typical for the majority of outputs is a **high fraction** of work done only by members of the department including experiments, calculations, theoretical background and interpretation with rather limited international or national collaboration.

5.2 Declaration on the involvement of students in research

Involvement of students (doctoral, undergraduate) into research

ISI CAS is not authorized to award academic titles (BSc, MSc, PhD) as such. It is however accredited as a scientific research workplace for the students of Masaryk University and Brno University of Technology. Experienced researchers at ISI CAS serve as students‘ PhD, MSc and BSc supervisors, approved by scientific boards at the respective universities. Students generally work on topics of their supervisors.
High level of the scientific work, experience of the researchers and many unique experimental instruments offer very good **opportunities** for many students.
During the evaluated period **1 Ph.D. thesis** was defended, together with **32 Master** thesis and **6 Bachelor**. This represents a good involvement of students. The department has **1 associated professor.** The students doing their work on thesis are predominantly supervised from lecturers form the university, not from the department.

Particular contributions of students to research

Students are involved into the research of the department within the frame of their bachelor, master and doctoral studies. Students are **significant** contributors to all scientific outputs at ISI CAS.
In the framework of various national projects, many doctoral and undergraduate students are introduced into the joint research team. They can do very useful scientific work and help their advisors in their research tasks. Collaboration with doctoral and undergraduate students often results in publications co-authored by the students. This kind of collaboration with Universities is very beneficial for the both contracting parties.

Number of defended PhD students in relation to students involved (success rate)

For the department No 2 there was 1 successfully defended. This represents **100% success rate**.

Supervision of students (Department No 2)

type of study	No of supervisors	No of consultants or co-supervisors	Theses defended in 2010-2014
Bachelor	4	0	6
Master	2	0	32
Doctoral (Ph.D.)	1	0	1

Employment of former Ph.D. students (career options)

Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students, including female students, are now members of the research team. The former Ph.D. students can continue their contract as so-called "post-docs".

5.3 Declaration on societal relevance

Societal relevance of the Department of New Technologies can be seen primarily through **collaborative and contract research** which contributes **significantly** to the **competitiveness of the national economy**. The department is well established in the region as a research group with application potential and has built a network of partners with long-term collaboration. The department has developed a number of technologies, instruments and methods that found their way into practice.

Impacts of the results and other activities on economy

The research of the department responds to actual needs of society in various areas contributing to increase of the competitiveness of Czech industry and cooperates on solution of various problems that have an impact on local industry with high added value. The contribution to the economy by the activities of the Group is thus very good. The Group has a broad collaboration with the industry on the basis of contractual research.
Research activities and their results have also very strong **impact** on the Institute economy – both institutional and grant parts of the budget depend on the quantity and quality of the outputs.
An **outstanding result** of applied research, development and technology transfer is the development and design of a micro–electron–beam machine MEBW–60/2 which was finished in 2007 and is now produced by the German company FOCUS GmbH under ISI's license.

Impacts of the results and other activities on education

The department members contribute also to teaching on various levels. Researchers participate actively in educational bachelor, master and doctoral programs mainly at Brno University of Technology. The department has **1 associated professor.** The involvement of departments in student supervision is also good.

Impacts of the results and other activities on culture

This impact should be in the field of applies physics and technology seen through propagation and promotion of science especially of technical subjects, which is now a national priority. Popularisation of science is mentioned below.

Outputs providing information relevant for public policy decisions in all fields of life

The institute is not dealing with social sciences or humanities, so this is not relevant.

Services for research (libraries, data bases, collections,..)

The institute has a large library which can also be used by external researchers. There are various types services for research.

Popularisation and similar activities

The Department No 2 participates (in the frame of the whole Institute) in activities of popularisation of science. There are contributions to Czech TV (2), Articles in newspapers and journals (2), Public lectures (2), Exhibitions (1), Autumn School of Electron Microscopy, each year: Week of Science and Technology of the CAS, Visitor‘s Days of the ISI. The evaluation commission judges the effort of the institute and particular teams in science popularisation as very good.

5.4 Declaration on the position in the international and national context

There is a unique expertise developed with respect to its scientific impact opens many cooperation opportunities (joint grant applications).

Comparison of the position, recognition, outputs and impacts with leading and international teams

Position of the group New Technologies in both national and international scientific community is very important. Research activities of the group have undoubtedly significant relevance not only in the national, but also in international context. The group New Technologies is leading in research and development of sophisticated technologies, high-tech instruments and their applications.

Role and position in international collaboration

The department is already doing an effort in identifying complementary foreign partners. The department should continue and increase this effort.

Breadth/completeness of the research activities compared to world leading teams of comparable size

In comparison with similar European laboratories doing technology oriented research, the output seen through the whole portfolio of outputs (including applied research, development of instrumentation, knowledge and technology transfer etc.) is well comparable.

Ability to attract foreign researchers at different levels

Incomparable financial conditions and moderate prestige of the institute limits significantly the possibility to attract foreign researchers including Ph.D. students from developed countries.
It is quite common to consider teams with a large portion of foreigners as desirable. On the other hand it is questionable whether it is really an advantage or whether it is in the rich countries only a

reflection of the fact that only a decreasing number of native young people are willing to do science. Here, fortunately, this problem (at least in Brno) is not so significant.

Possible missing research directions

There are no missing research directions.

Position of the team in the national context

Position of the department both national and international scientific community is very important. The department belongs to leading groups at the national level with established collaborations with several Czech teams mainly at universities and companies as well. The number of contractual research and research projects funded by grant agencies confirms this statement.

5.5 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience

The **age structure** of this department is of a very good distribution including students, young researchers, post docs, research fellows and senior researchers with the best qualifications reachable in the Czech Republic, which is further improved by a direct collaboration with foreign institutes. Nevertheless, the structure suffers from a lack of directly employed foreign researchers and Ph.D. students. There is only one female researcher.
The Institute provides financial incentives to research teams successful in solicitation research funding or contractual research.

Attraction of research programmes for young people

The research programmes seem very attractive for young people. The research groups use modern methods and unique facilities.

Funding (structure of the resources and its comparison with the outputs, grants and project activity

The **structure of funds** of the department is dominated by project funding. with small contribution from the institutional funding. More significant contribution is represented by contractual research. This introduces a **uncertainty** to the funding. A key impulse that moved the whole institute towards project funding was participation within the EU project from structural funds **ALISI**. It helped the institute to build new laboratories, purchase new, state-of-the-art equipment and hire more people.

Effectiveness of research (based on comparing size of groups, funding and output)

The output of the department seen through the number of publications, scientific instruments, and methodologies is good or very good. Average number of about 0.5 publication/year/1FTE(researcher) in journal with IF is not fully sufficient for a department of

such a quality. In technology oriented research the efficiency should be judged also through societal impact on the economy, which is very good (see above).

Organisational structure, recruitment methods, career system, incentives for females, young researchers, international researchers

Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students, including female students, are now members of the research department. The former Ph.D. students can continue their contract as so-called "post-docs". Incomparable financial conditions limits significantly the possibility to attract foreign researchers including Ph.D. students from developed countries.

5.6 Declaration on the strategy and plans for the future

Relevance of the out lined strategy and research plans

Detailed research plan of the department New Technologies for 2015-2019 is prepared in **details**. Plan of the department is especially based on its human resources and budget. The department will continue in participation of existing three directions. The basic policies of the department as well as the Institute will be focused mainly on institutional support of grant applications, efficient use of existing experimental equipment, and support for the rising interdisciplinary research, openness towards commercialization of research results.

Adequacy of available means and human resources to achieve these plans

The **capabilities** of the existing research department are very good. Supplementary recruitment of researchers can be necessary maybe later. Obtaining **supplementary funding** will also be necessary.
The department wants to maintain the general organizational structure of the ISI departments, but to be flexible enough to support new scientific directions for strong individuals or projects, so that new groups can be formed. Also they want to **follow the healthy common sense** and keep a friendly and cooperative atmosphere at ISI so that everybody can enjoy the creative work.

Missing issues in the strategy

There are no missing issues, provided that the department is serious about setting up strategic **co-operations with industry and foreign research teams** with the objective of acquiring funding from EU sources.

EVALUATION OF THE INSTITUTE OF SCIENTIFIC INSTRUMENTS

Dept. of Magnetic Resonance and Cryogenics

This report refers to the Evaluation of the Institute Scientific Instruments (ISI) – Department of Magnetic Resonance and Cryogenics - of the Academy of Sciences of the Czech Republic, 2010-2014, and is written according the to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS. This evaluation is based on the materials provided from the Institute of Scientific Instruments and from their particular Departments, from the web pages [www.isibrno.cz], from particular presentations, and last but not least from discussions with researchers and management of the Institute (all within the "on site visit" on October 19, 2015).

1. INTRODUCTION

There are 2 groups within the Team of **Magnetic resonance and cryogenics**:
1. The Group of Magnetic Resonance
2. The Group of Cryogenics and Superconductivity

1.1 Location of the institute and its dept., labs. & sub units.

Laboratories and the other facilities of this department are in the main building of the Institute (Královopolská 147, 612 64 Brno).

1.2 Brief history of the institute (department)

The Nuclear Magnetic Resonance (NMR) Department at ISI was founded in 1960 by J. Dadok, the designer of the **first NMR spectrometer** working at a frequency of 30 MHz, later produced by TESLA Brno since 1966. This was the only production of its kind in any of the Eastern European countries and continued for 25 years. These spectrometers were an extremely successful export article and several hundreds of various types were produced, based on the R&D provided by ISI.
In 1967 a laboratory for low-temperature technology oriented towards the R&D of super-conducting magnets for NMR was established by J. Jelínek. After J. Dadok's emigration the department was led by K. Švéda and later (until 1990) by Z. Starčuk. In the 1970s the department began to deal with more methodological problems, for example Fourier pulse spectrometry, under the supervision of Z. Starčuk and V. Sklenář. The most significant achievements included a number of firsts in the field of NMR experiment methodology.
[Based on materials provided and materials from www.isibrno.cz]

1.3 Mission and research topics

Involvement of the department in the Strategy of the CAS AV21

The research programme "Diagnostic Methods and Techniques" of the new Strategy AV21 includes several research topics, or sub-programmes. The Department of Magnetic Resonance and Cryogenics is involved in one of them, called "Liquid matter systems and low temperature physics for biology and space research", which is coordinated by Aleš Srnka from the Department of Magnetic Resonance and Cryogenics, ISI.

1. Group of Magnetic Resonance

Mission of the team:

The **primary goal** of the team of Magnetic Resonance is the development of measurement methods and technologies for biomedical and also technical applications of nuclear magnetic resonance and to the application of MR techniques in preclinical, particularly translational research utilizing mouse and rat animal models of neurologic, psychiatric and oncologic diseases. The current research emphasizes:

- measurement of organ perfusion and pharmacokinetic modelling
- heart electrophysiology
- spatially localized MR spectroscopy (MRS) and spectroscopic imaging (MRSI), including metabolite quantitation and computer simulation
- characterization and tracing of contrast agents in vitro and in vivo, aiming at targeted transport of nanoparticles
- MR-based morphometry
- multiparametric data analysis

The experimental research is based on a modern 9.4T MR system Bruker Biospec 94/30, equipped for multinuclear preclinical imaging, and an accredited mouse and rat animal facility. Also a 4.7T MR imaging system is available. The group closely collaborates with other subjects (Masaryk University, Veterinary Research Institute and others), which ensures the multidisciplinary needs of preclinical research employing MR. Translation of the techniques to clinical practice is another part of the research interests.

Research areas – thematic research focus:

- nuclear magnetic resonance imaging
- nuclear magnetic resonance spectroscopy in vivo
- MR for preclinical research with small laboratory animal models
- MR imaging for medical diagnostics
- MR for material research and development

Excellence in the area:

- MR spectroscopy in vivo – spin system simulation, pulse sequence development.
- MR measurement of perfusion – pharmacokinetic modelling.

2. The Group of Cryogenics and Superconductivity

Mission of the team:

The **primary goal** of the team of Cryogenics and Superconductivity is concentrated on the optimization of the helium cryogenic systems, especially on the possibilities of reduction of the undesirable heat flows. The heat flows are analyzed by special numerical methods. In the area of superconductivity the group is concerned with the development and generalization of design

approaches enabling realization of magnetic systems that generate effectively magnetic fields with the defined space configuration.
The team sees its **mission** in elucidation of natural turbulent convection in cryogenic experiments considering the fact that a general theory of turbulence which is still absent, in broadening of a unique database of thermal-radiative properties of materials used in cryogenics and validation of theoretical model of the near-field effect at low temperatures for different materials.

Research areas – thematic research focus:
- Cryogenics
- Low temperature physics
- Fluid dynamics, turbulence
- Applied superconductivity

Excellence in the area:
- Characterization of thermal-radiative properties of materials at low temperatures
- Experimental study of near-field effect at low temperatures
- Basic research in fluid dynamics – Rayleigh-Bénard convection
- Design and optimization of cryogenic systems

1.4 Staff size and full time equivalents age distribution

The Department No 3 (Magnetic Resonance and Cryogenics) is of medium size within the Institute of Scientific Instruments. The sum of the full time equivalents (FTE) as of December 31, 2014:
technical workers: 8,4 (14 persons)
researchers 10.46 (25 persons)

Age structure of the Department 3 [under the Institute Report]

Age	<25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	>70
number	1	7	3	3	0	2	1	3	1	2	2

Result: more than 60% of scientists of the Department of MRC have age between 25 and 50 years and about one-fourth of staff are students.

2. STRENGTHS AND OPPORTUNITIES

2.1 Timeliness of research topics

The research topics seem all **well-chosen**. The Team deals with modern topics combining experimental research, applications, and clinical research. Most of the department research topics are very exacting and perspective both from the theoretical and application point of view. They represent top research areas in the current physics, engineering, even medicine, biology, and material sciences. The general research topics are relatively stable.

2.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The department is **partially project funded** (including all salaries of the staff) so it relies on a projects as well as on the institutional funding. This portion of money is from various grant projects and from collaborative research. This composition is not reasonable and optimal.

Activities of the Team No 3 concerning projects

	2014	
Institution money	71	23%
Project budget (kEUR)	224	74%
Contractual research (kEUR)	9	3%

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

The research Department No 3 collaborates with another departments and teams of the Institute, the collaboration among them depends on the current needs and possibilities, e.g., utilization of the special instruments, joint participation on the projects etc.
Collaboration of the department with other partners is very wide and is primarily with the University hospital of the Masaryk University, CEITEC, biology and medical institutes of the CAS, and abroad with the University of Manchester, Radbound University Nijmegen, Catholic University Leuven, Ecole Polytechnique Lausanne, and others.

2.4 Position of the institute within the Czech scientific community and its international position

The Team of Magnetic Resonance and Cryogenics **efficiently cooperates** with universities, hospitals and companies that form the portfolio of end-users for the department research. Position of the Team as well as Institute within the Czech scientific community in the aforementioned research areas in the top level thanks to a unique combination of theoretical NMR expertise, experimental background and computer programming abilities.
The international cooperation is very relevant and directs to University of Manchester, Radbound University Nijmegen, Catholic University Leuven, Ecole Polytechnique Lausanne, CERN and others. The Department Magnetic Resonance and Cryogenics participates in international projects ESFRI Euro-Bioimaging and European FP6 Marie-Curie project FAST (2007-2010)

2.5 The overall capacity of staff

The Team has 14 researchers, 10 Ph.D. students, and 14 technical and other workers. Stable number of researchers with increasing FTE - continually increasing number of employees during the evaluation period is obvious from materials provided. The capacity and composition is well adjusted to the mission and goals of the department and responds to specific needs of running of the research infrastructure.
Composition of the department reflects its multidisciplinary goals and includes physicists, engineers, IT specialists, biologists, chemists, specialists on veterinary medicine and technicians.

2.6 Comments on the age structure

The Department No 3 (Magnetic Resonance and Cryogenics) is of medium size within the Institute of Scientific Instruments. More than 60% of scientists of the Department of MRC have age between 25 and 50 years and about very good age structure of the scientific department with increasing number of research members including young researchers makes a promising background for the future development of the Team. From 10 Ph.D. students there are 2 foreigners. Part of females is circa 30 % (of persons).

2.7 Frequency and quality of publications

Frequency of publications **is adequate** to the specific field of "Instruments and instrumentation research". Scientometric studies comparing domestic and international quality and amount of publications within narrow research specializations have shown that this publication activity is **well comparable with the European standard**. During the 2010-2014 period, there were published papers in journals with IF (52 in total), papers in other journals (8 pieces), and papers at conferences (87). There were 14 applied results. In the Evaluation Phase I, five selected publication was classified as world-leading, 10 as internationally excellent, and 4 as internationally recognized. This shows that the quality of the publications is very good**.** The **overall outputs** of the department together with other results and contributions to the medical research with outstretch to applications in medical care must be judged as good.

Team of MRC – results during the period 2010 – 2015

	Team of Magnetic Resonance and Cryogenics
Papers in journals with IF	52
Papers in other journals	8
Scientific books	0
Papers at conferences	87
Patents	0
Applied results	14
Number of scientists	10,48
Number of other workers in department	4,31

2.8 Patents and role in contractual work

During the 2010-2014 period no patents was supplied by the department but there is some contract research work (9 kEUR). Contractual work can be a source of significant incomes. The role of the Institute on contractual work is generally not related to patents but in the solution of practical problems. The amount of time and resources coming from contractual research is limited with respect of the other source of budget.

3. WEAKNESSES AND THREATS

3.1 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The department is **partially project funded.** It is a product of the research environment in the Czech Republic with a large portion of purpose (project funding). A key impulse that moved the whole

institute towards project funding was participation within the EU project from structural funds **ALISI**. It helped the institute to build new laboratories, purchase new, state-of-the-art equipment and hire more people.
The Comment of the Commission: The department as well as the whole Institute would prefer a larger part of the funding provided directly by the Academy of Sciences, without competition. The evaluation commission understands that it would be much more comfortable for the institute to have a larger amount of non-competitive funding. It can support the stability of the research department from the point of view of staff and research directions.
A threat, to which most research teams in western and middle Europe are confronted with, including the Institute of Scientific Instruments, is the tendency for reduction of the funding possibilities on the national level and thus the necessity to be more successful in projects with EU funding or international funding. The institute is fully aware of this necessity and has **succeeded** in participating in several EU projects, with considerable funding for acquiring research equipment. Clearly, continued efforts in trying to participate in EU projects are necessary

3.2 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

Even though the number of international (mainly European) projects increases at ISI, still the majority of financial support comes from the local national resources. On the other side informal cooperation with foreign partners is in case of the Department of Magnetic Resonance and Cryogenics at a very good level. The staff is partially international with three foreigners which is under these conditions a good number.

4. RECOMMENDATIONS

4.1 Re-organization of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

At the moment we **do not recommend** some type of re-organization of the internal structure of the Department No 3. It must be prepared to solve new research topics in future. For these purposes it is desirable to look for other adequate personal and financial sources in the future.

4.2 Internal programs to stimulate actions to enforce strengths and to reduce weaknesses

Within the Institute they have various programs to enforce strengths and to reduce weaknesses. Emphasis is on contributions in high quality journals. There are internal programs and incentives to stimulate a conversion of results from conference contributions into regular journal articles. Focus on strengthening of international collaboration. The teams are under the supervision The Director and The Council.

4.3 Identification of new research topics

The research plan of the whole institute (for 2015–2019) sets the main goal to utilize researches' intellectual potential and up-to-date equipment and enhance existing methods of investigation of nanoworld, microworld and macroworld in the relevant areas of physics, biology, medicine and

engineering. There does not seem a direct need to search for another new research topics. These come spontaneously. Relevance of the plans is limited by funded grants and projects.
The **most important trends** within the group of Magnetic resonance and cryogenics are as follows:

- Provision and interpretation of experimental MR data (from 9.4T and 4.7T ISI scanners), development of targeted delivery of drugs and diagnostic markers and early-stage diagnostics of neurodegenerative diseases (within project Czech-Bioimaging, related to an ESFRI project Euro-Bioimaging)
- Implementation and development of own methods in the 9.4T scanner to master fast multivoxel spectroscopy, fast spectroscopic imaging, phase-sensitive parallel detection, artefact identification and avoidance
- Perfusion techniques will be developed to higher reliability and mutually consistent results; multiparametric MR and also ulrasound imaging will be used.
- Further development of jMRUI software tool under coordination of ISI experts
- The department will wish to handle also the emerging biological needs: Resting-state functional MRI, Quantitative MRI in general, Multiparametric combinations of several MR techniques for the studies of interest (Parkinson's, Alzheimer's disease, epilepsy, schizophrenia, dilatation cardiomyopathy, subarachnoid haemorrhage, septic encephalopathy, tumours).
- Possible synergies with the EM, CO and OMT teams will be explored inside ISI to implement new methods or modalities to existing MR ones • Utilization of hyperpolarized 129Xe for early Alzheimer's and Parkinson's disease (in collaboration with EU partners)
- Deeper understanding of the near-field heat transfer between superconducting surfaces and its experimental measurement
- More precise measurement of Rayleigh-Bénard convection in new helium cryostat
- Participation in the program COMPASS approved by the CERN Research Board
- Enlargement of the database of surface thermal emissivities and absorptivities

5. DETAILED EVALUATION

5.1 Declaration on the quality of the results and share in their acquisition

Characterisation of the main research activities (experiments, theoretical areas)

The main research activities of the Team have **very complex** character and they include both theoretical approaches and sophisticated experimental research. Main results can be shortly divided into three groups, reflecting the division of the Team into three groups.

Relevance in the national and international context

Research activities of the Institute and the Dept. of Magnetic Resonance and Cryogenics have undoubtedly very important relevance not only in the national, but also in international context. In the case of the Dept. of Magnetic Resonance and Cryogenics the intensity of cooperation mentioned above proves the relevance. The department is **unique** with respect to complex experimental and methodological expertise in magnetic resonance spectroscopy and imaging going down to fundamental physics and technology of instrumentation.

Overall quality of publications

Scientific outputs of the department researchers have generally of very good **quality**. The majority of evaluated publications belongs to internationally (19) and nationally recognized outputs (2). Among world-leading publications there are 5 papers. Nine papers are published in top decile (1*) and quartiles 1-2 by AIS of journals (12 + 2). These facts were confirmed in the Evaluation Phase I. Also intensity of citations of these publications is on average level.

Specification of the main achievements

- quantum-mechanical simulation of coupled spin systems module NMRScopeB, a tool for the preparation of basis signals for metabolite quantitation
- improvement of quantitative determination of pharmacokinetic model parameters
- a series of measurements as parts of animal model validation in Parkinson's disease and two models of schizophrenia.
- development of calculation methods for the analysis of these heat flows; a set of numerical procedures for the calculation of steady temperatures and heat flows on PC has been created and is improved constantly; a program KRYOM 3.3 based on the procedures enables one to analyses and optimize usual cryogenic devices
- development of special devices for the measurements of the emissivity coefficients at low temperatures
- small helium cryopump has been developed for electron optical devices; it contains a bath of 3 liters of liquid helium and 3.4 liters of liquid nitrogen, refill intervals of over 30 days for helium and 5 days for nitrogen were achieved; the pumping properties are tested

Specification of the contributions of the team to publications

The **contribution to the results** presented within the evaluation is in all cases a sole or a majority. In all collaborative projects the share of the department is dominant. No result is a product of any collaboration where the department might be only a small contributor.

5.2 Declaration on the involvement of students in research

Involvement of students (doctoral, undergraduate) into research

ISI CAS is not authorized to award academic titles (BSc, MSc, PhD) as such. It is however accredited as a scientific research workplace for the students of Masaryk University and Brno University of Technology. Experienced researchers at ISI CAS serve as students' PhD, MSc and BSc supervisors, approved by scientific boards at the respective universities. Students generally work on topics of their supervisors.
High level of the scientific work, experience of the researchers and many unique experimental instruments offer very good **opportunities** for many students.
During the evaluated period **5 Ph.D. thesis** were defended, together with **16 Master** thesis and **13 Bachelor**. This represents a very good involvement of students.

Particular contributions of students to research

Students are involved into the research of the department within the frame of their bachelor, master and doctoral studies. Students are **significant** contributors to all scientific outputs at ISI CAS.
In the framework of various national projects, many doctoral and undergraduate students are introduced into the joint research team. They can do very useful scientific work and help their advisors in their research tasks. Collaboration with doctoral and undergraduate students often results in publications co-authored by the students. This kind of collaboration with Universities is very beneficial for the both contracting parties.

Number of defended PhD students in relation to students involved (success rate)

For the Department No 3 there were 5 successfully defended and 18 Ph.D. students have been involved in the department. The success rate of those who ended their study is close to **100%**, the table below includes those, who started their study in this period but did not finish it yet (they still go on studying.

Supervision of students (Team MRC)

type of study	No of supervisors	No of consultants or co-supervisors	Theses defended in 2012-2014
Bachelor	13	0	13
Master	17	0	16
Doctoral (Ph.D.)	18	1	5

Employment of former Ph.D. students (career options)

Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students are now members of the research department. The former Ph.D. students can continue their contract as so-called “post-docs”.

5.3 Declaration on societal relevance

Societal relevance of the Department of Medical signals can be seen primarily through **applied research** (collaborative and contract based) which contributes **significantly** to the **competitiveness of the national economy and health care**. The department is well established in the region as a research group with application potential and has built a network of partners with long-term collaboration. The department has developed a number of instruments and methods for medical measurement and diagnostics.

Impacts of the results and other activities on economy

The research of the department responds to actual needs of society through development of methods of effective medical treatment and diagnostics. The methodology oriented research is very important for partners especially in health care and medical research thanks to a **unique** combination of theoretical NMR expertise, experimental background and computer programming abilities.

This can be seen through their inclusion within the framework of ESFRI project **Euro-Bioimaging.**

Impacts of the results and other activities on education

The Team members contribute also to teaching on various levels. Researchers participate actively in educational bachelor, master and doctoral programs mainly at Masaryk University and Brno University of Technology. The involvement of departments in student supervision is also very good.

Impacts of the results and other activities on culture

This impact should be in the field of applies physics, medicine, and technology seen through propagation and promotion of science especially of technical subjects, which is now a national priority. Popularisation of science is mentioned below.

Outputs providing information relevant for public policy decisions in all fields of life
The institute is not dealing with social sciences or humanities, so this is not relevant.

Services for research (libraries, data bases, collections,..)

The institute has a large library which can also be used by external researchers. There are various types of services for research.

Popularisation and similar activities

The Team No 3 participates (in the frame of the whole Institute) in activities of popularisation of science. There are contributions to Czech TV (2), public lectures (3), each year: Visitor‘s Days of the ISI.
The evaluation commission judges the effort of the institute and particular teams in science popularisation as very good.

5.4 Declaration on the position in the international and national context

There is a unique expertise developed with respect to its scientific impact opens many cooperation opportunities (joint grant applications).

Comparison of the position, recognition, outputs and impacts with leading and international teams

Position of the Department Magnetic Resonance and Cryogenics in both national and international scientific community is very important. Research activities of the group have undoubtedly very important relevance not only in the national, but also in **international context** (mainly cooperation with foreign partners University of Manchester, Radbound University Nijmegen, Catholic University Leuven, Ecole Polytechnique Lausanne, CERN and

others). The Department Magnetic Resonance and Cryogenics is leading in a unique combination of theoretical NMR expertise, experimental background and computer programming abilities. At the moment the group activities are balanced between the fundamental research and applied research oriented to methodology for medical applications.

Role and position in international collaboration

The department is very well **integrated** into international cooperation, especially thanks to participation in the framework of the ESFRI project **Euro-Bioimaging** with the top medical research institutions and international research partners and thanks to joining European FP6 **Marie-Curie project FAST** (2007-2010), the pan-European activity for the development of spectroscopic quantitation software jMRUI, and particularly its spin system simulation segment.

Breadth/completeness of the research activities compared to world leading teams of comparable size

The department should be compared to their partners in international cooperation. Its special position combining theoretical NMR expertise, experimental background and computer programming abilities makes it difficult to compare directly. Seen predominantly as a team doing research in technical sciences the publication activity is not the only factor to compare performance, it has to be seen through the **whole portfolio of research outputs** including applied research, development of instrumentation, knowledge and technology transfer etc. From this point of view the outputs are good.

Ability to attract foreign researchers at different levels

The Department Magnetic Resonance and Cryogenics includes **3 foreign members** which is very good number for the standards of the Institute (and Brno as well). This has been supported also by a project European FP6 Marie-Curie grant FAST (2007-2010).

Possible missing research directions

There are no missing research directions.

Position of the team in the national context

Position of the Team both national and international scientific community is very important and unique. The Team belongs to leading groups at the national level with established collaborations with several teams mainly universities and hospitals thanks to the unique combination of theoretical NMR expertise, experimental background and computer programming abilities.

5.5 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience

The **age structure** of this small department is of a very good distribution including students, young researchers, post docs, research fellows and senior researchers with the best qualifications reachable in the Czech Republic, which is further improved by a direct collaboration with foreign institutes (University of Manchester, Radbound University Nijmegen, Catholic University Leuven, Ecole Polytechnique Lausanne, CERN and others). There are **3 foreign members** of the department and a significant (**largest in the ISI**) portion of **female department members (38%)**, maybe thanks to the focus on medical applications.

Attraction of research programmes for young people

The research programmes seem very attractive for young people. The research groups use modern methods and unique facilities. Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students, including female students, are now members of the research department. The former Ph.D. students can continue their contract as so-called "post-docs".

Funding (structure of the resources and its comparison with the outputs, grants and project activity

The **structure of funds** of the department is dominated by project funding with contribution by contractual research. This introduces an **uncertainty** to the funding. A key impulse that moved the whole institute towards project funding was participation within the EU project from structural funds **ALISI**. It helped the institute to build new laboratories, purchase new, state-of-the-art equipment and hire more people.

Effectiveness of research (based on comparing size of groups, funding and output)

The output of the Team in number of publications, scientific instruments, and methodologies is very good. The outputs of department is only partially in publications the applied research outputs has to be taken into account and thus the overall output is really very good.

Organisational structure, recruitment methods, career system, incentives for females, young researchers, international researchers

Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students, including female students, are now members of the research department. The former Ph.D. students can continue their contract as so-called "post-docs".

5.6 Declaration on the strategy and plans for the future

Relevance of the out lined strategy and research plans

Research plan of the Department of Magnetic Resonance and Cryogenics for 2015-2019 **is prepared in great detail**. Plan of the department is especially based on its human resources and budget. The department will continue in participation of existing research directions.

The basic policies of the department as well as the Institute will be focused mainly on institutional support of grant applications, efficient use of existing experimental equipment, and support for the rising interdisciplinary research, openness towards application of research results.

Adequacy of available means and human resources to achieve these plans

The **capabilities** of the existing research department are **very good**. Supplementary recruitment of researchers can be necessary maybe later. Continuing in the effort to keep **supplementary funding** is also necessary.
The department wants to maintain the general organizational structure of the ISI departments, but to be flexible enough to support new scientific directions for strong individuals or projects, so that new groups can be formed. Also they want to **follow the healthy common sense** and keep a friendly and cooperative atmosphere at ISI so that everybody can enjoy the creative work.

Missing issues in the strategy

There are no missing issues, provided that the department is serious about setting up strategic **co-operations with partners and foreign research teams** with the objective of acquiring funding from EU sources.

EVALUATION OF THE INSTITUTE OF SCIENTIFIC INSTRUMENTS

Dept. of Medical signals

This report refers to the Evaluation of the Institute Scientific Instruments (ISI) – Department of Medical signals - of the Academy of Sciences of the Czech Republic, 2010-2014, and is written according the to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS. This evaluation is based on the materials provided from the Institute of Scientific Instruments and from their particular departments, from the web pages [www.isibrno.cz], from particular presentations, and last but not least from discussions with researchers and management of the Institute (all within the "on site visit" on October 19, 2015).

1. INTRODUCTION

1.1 Location of the institute and its dept., labs. & sub units.

Laboratories and the other facilities of this department are in the main building of the Institute (Královopolská 147, 612 64 Brno).

1.2 Brief history of the institute (department)

The Department of Medical Signals has dealt with measurement and signal processing in medicine for a long time. Twenty years ago, they began a widespread close cooperation with medical workplaces and universities. This cooperation is absolutely crucial to meet chosen objectives.
[Based on materials provided and materials from www.isibrno.cz]

1.3 Mission and research topics

Involvement of the department in the Strategy of the CAS AV21
The research programme "Diagnostic Methods and Techniques"of the new Strategy AV21 includes several research topics, or sub-programmes. The Department of Medical Signals is involved in one of them, called "Advanced non-invasive diagnostics procedures for human and veterinary medicine and biology", which is coordinated by Pavel Jurák, head of the Department of Medical Signals, ISI together with Jiří Homola, director of the Institute of Photonics and Electronics, Lucie Kubínová, director of the Institute of Physiology, and Pavel Dráber from the Institute of Molecular Genetics.

Mission of the department:
The **primary goal** of the department of medical signals is the use of the last achievement of the technology in medicine for basic research and for effective treatment. The department tries to find the optimal targeted link between high level measurements, measurement protocols, methods of analysis

and diagnostic and physiological contribution. The data acquisition and technologies, which carry additional information, is absolutely crucial.
Running the Medical Signals department research includes three principal areas:

- blood circulation and hemodynamic control
- heart electrophysiology
- deep brain electrophysiology

Mission of the department lays in development of new measurement techniques and analytical procedures for brain activity mapping and treatment of epileptic patients and diagnostic procedures for noninvasive, cheap, comfortable and early diagnosis of cardiovascular system diseases. Researchers from the department **contributed to development of a number of medical methods and instruments** for diagnostic and treatment of diseases in the field of neurology in general, epileptic patient treatment, dementia diseases, cardiology in general, heart failure, arrhythmia, heart attack, ischemic disease, blood vessel stiffness and properties of blood circulation.

Research areas – thematic research focus:

- Non-invasive cardiology
- Scalp and intracerebral neurology
- Medical signal processing
- Medical acquisition systems
- Experimental devices – ECG monitors, amplifiers, whole body plethysmography
- Testing and verification of new diagnostics procedures

Excellence in the area:
Analysis and statistical evaluation of EEG recordings from deep brain structures, circulation control and hemodynamics, cardio electrophysiology.

1.4 Staff size and full time equivalents age distribution

The department No 4 (Medical Signals) is the smallest at the Institute. The sum of the full time equivalents (FTE) as of December 31, 2014:
technical workers: 3.06 (5 persons)
reseachers 5.19 (6 persons)
Ph.D. students 1.78 (2 persons) + 8 external

Age structure od the Team 1 [under the Institute Report]

Age	<25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	>70
number	0	1	1	1	2	1	1	0	0	1	2

Result: Almost uniform distribution with gaps between 55 and 60 years. Only one foreign employee (Slovakia). As usual in technical sciences, the department is male dominated, 8 Ph.D. students include also 3 women.

2. STRENGTHS AND OPPORTUNITIES

2.1 Timeliness of research topics

The research topics seem all **well-chosen**. The department deals with modern topics combining experimental research, applications, and clinical research. Most of the department research topics are very exacting and perspective both from the theoretical and application point of view. They represent top research areas in the current physics, engineering, even medicine, biology, and material sciences. The general research topics are relatively stable.

2.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The department is **predominantly project funded** (including all salaries of the staff) so it has to rely on a large number of diverse projects. This diversity can be also seen as a threat. A significant portion of purpose funding comes from the infrastructure EU project of structural funds **ALISI**. It helped the institute to build new laboratories, purchase new, state-of-the-art equipment and hire young people.

Activities of the Department No 4 concerning projects

	2010	2011	2012	2013	2014
Projects	6	4	4	3	4
Project budget (kEUR)	3084	2155	4467	7285	5163

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

The research department No 4 collaborates with another departments and teams of the Institute, the collaboration among them depends on the current needs and possibilities, e.g., utilization of the special instruments, joint participation on the projects etc.
Collaboration of the department is primarily with the University hospital of the Masaryk University and its University hospital and international with Mayo Clinic in Rochester, USA, then also with University of Rochester, USA. The collaboration is very intensive and fruitful.

2.4 Position of the institute within the Czech scientific community and its international position

Due to its multidisciplinary orientation on methodologies, the department **efficiently cooperates** with universities, hospitals and companies that form the portfolio of end-users for the department research. The Department of Medical Signals tries to find the optimal targeted link between high level measurements, measurement protocols, methods of analysis and diagnostic and physiological contribution. The data acquisition is absolutely crucial (and necessary technologies, which carry additional information). The department is leading in development of this type of sophisticated technologies. Position of the department as well as Institute within the Czech scientific community in the aforementioned research areas in the top level and many of the research results obtained are **original and essential** on an international scale.

2.5 The overall capacity of staff

The department No 4 (Medical Signals) is the smallest at the Institute. The bio-signal acquisition and processing belongs to highly multidisciplinary fields. ISI represents a **unique place** where the fundamental research in selected areas of physics, chemistry, biology, medicine is directly combined with advanced engineering skills in machinery, electronics and programming on the long-term basis.

2.6 Comments on the age structure

More than 1/2 employees involved in research are younger than 50 years and represent the pool for future group leaders and experts. Age structure of the department No 4 (Medical Signals) has almost uniform distribution with gaps between 55 and 60 years. There is only one foreign employee (Slovakia). Otherwise very good age structure of the scientific department with increasing number of research members including young researchers makes a **promising background** for the future development of the Group.

2.7 Frequency and quality of publications

Frequency of publications is adequate to the specific field of "Instruments and instrumentation research". Scientometric studies comparing domestic and international quality and amount of publications within narrow research specializations have shown that this publication activity is well comparable with the European standard. During the 2010-2014 period, there were published papers in journals with IF (19 in total), papers in other journals (4 pieces), and papers at conferences (21). There were 5 applied results. In the Evaluation Phase I, two selected publication was classified internationally excellent, and 5 as internationally recognized.

Department of Medical Signals – results during the period 2010 – 2015

	Department of Medical Signals
Papers in journals with IF	19
Papers in other journals	4
Scientific books	0
Papers at conferences	21
Patents	2
Applied results	5
Number of scientists	5.04
Number of other workers in team	2.57

2.8 Patents and role in contractual work

During the 2010-2014 period 2 patents was supplied by the department. There is only small contract research work (2 kEUR). Contractual work was not a source of significant incomes. The role of the Institute on contractual work is generally not related to patents but in the solution of practical problems. The amount of time and resources coming from contractual research is limited with respect of the other source of budget.

3. WEAKNESSES AND THREATS

3.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The department is **predominantly project funded.** It is a product of the research environment in the Czech Republic with a large portion of purpose (project funding). The Comment of the Commission: The department as well as the whole Institute would prefer a larger part of the funding provided directly by the Academy of Sciences, without competition. The evaluation commission understands that it would be much more comfortable for the institute to have a larger amount of non-competitive funding. It can support the stability of the research department from the point of view of staff and research directions.
A threat, to which most research teams in western and middle Europe are confronted with, including the Institute of Scientific Instruments, is the tendency for reduction of the funding possibilities on the national level and thus the necessity to be more successful in projects with EU funding or international funding. The institute is fully aware of this necessity and has succeeded in participating in large EU projects, with considerable funding for acquiring research equipment. Clearly, continued efforts in trying to participate in EU projects are necessary.

3.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

Even though the number of international (mainly European) projects increases at ISI, still the majority of financial support comes from the local national resources. On the other side informal cooperation with foreign partners is in case of the department of Medical signals at a very good level, slightly more than 1/3 of publications with IF are with authors from abroad. The staff is only partially international with one foreigner – this relatively low number reflects on one hand a limited chance to attract foreigners from richer countries while keeping acceptable social balance between foreigners and Czechs at the corresponding level of work productivity and on the other hand still persisting will of native young people to do science. This, fortunately, makes this problem (at least in Brno) is not so significant.

4. RECOMMENDATIONS

4.1 Re-organization of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

At the moment we **do not recommend** some type of re-organization of the internal structure of the department No 4. It must be prepared to solve new research topics in future. For these purposes it is desirable to look for other adequate personal and financial sources in the future.

4.2 Internal programs to stimulate actions to enforce strengths and to reduce weaknesses

Within the Institute they have various programs to enforce strengths and to reduce weaknesses. Emphasis is on contributions in high quality journals. There are internal programs and incentives to stimulate a conversion of results from conference contributions into regular journal articles. Focus on

strengthening of international collaboration. The teams are under the supervision The Director and The Council.

4.3 Identification of new research topics

The research plan of the whole institute (for 2015–2019) sets the main goal to utilize researches' intellectual potential and up-to-date equipment and enhance existing methods of investigation of nanoworld, microworld and macroworld in the relevant areas of physics, biology, medicine and engineering. There does not seem a direct need to search for another new research topics. These come spontaneously. Relevance of the plans is limited by funded grants and projects.
The **most important trends** within the group of Medical Signals are as follows:

- Finalization of technologies based on of high dynamic and high frequency range acquisition system (UHF-ECG developed at ISI), their clinical validation and related research in the areas of blood circulation and hemodynamic control, heart electrophysiology and brain electrophysiology (with FNUSA-ICRC shielded labs)
- Utilization of multichannel whole body impedance plethysmography (developed at ISI) in detection of blood circulation and system regulation in the human body
- Improvement of clinical diagnosis of congenital LQTS using new mathematical method for evaluation of dynamic parameters of QT/RR relationship
- Analysis of high-frequency oscillations in deep brain electrophysiology
- Deployment of ISI software tools at cooperating FNUSA-ICRC facility

5. DETAILED EVALUATION

5.1 Declaration on the quality of the results and share in their acquisition

Characterisation of the main research activities (experiments, theoretical areas)

The main research activities of the department have **very complex** character and they include both theoretical approaches and sophisticated experimental research.

Relevance in the national and international context

Research activities of the Institute and particular Teams have undoubtedly very important relevance not only in the national, but also in international context. Results were received within the frame of Czech research projects, international projects, and international cooperation. The department is **unique** with respect to complete expertise in medical signal processing. It is successful in many national project applications

Overall quality of publications

Scientific outputs of the department have generally good quality. The majority of evaluated publications belongs to internationally (7) and nationally recognized outputs (3). Five papers are published in quartiles 1-2 by AIS of journals (1 + 4). These facts were confirmed in the Evaluation Phase I. Also intensity of citations of these publications is on average level.

Publication activity of the Institute researches is lower per researcher in comparison with other CAS institutes. For many years the department was mainly focused on development of high-tech instruments and medical signal processing.

Specification of the main achievements

The key results of research projects are in a following short overview:

- A completely new technique for hemodynamic diagnostics with newly developed multichannel, whole-body impedance monitor, MPM; the result of the department include complete technology design and construction, experimental measurement management and data evaluation, analysis and interpretation.
- Investigation of various aspects of QT/RR relationship and development of new method of dynamic parameters analysis. Two parameters (GainF and τ) describe newly analyzed physiological characteristics of QT interval.
- The ventricular (LV) dyssynchrony quantification; a high dynamic range ultra-high frequency ECG (UHF-ECG 250–2000 Hz) technique followed by new analytical procedures complete design and implementation of new technologies was introduced including: a high dynamic acquisition system, new software for the analysis of UHF-ECG, interpretation of results and diagnostic applications.
- New methods of measurements from depth electrodes regarding the activity of the brain and the nervous system together with design and verification of methods for identification of epileptic sources within the brain through pathological High-Frequency-Oscillations (HFOs).
- Software designed by the department:
    - PulsWave – Software evaluating pulse wave velocity in blood stream
    - SignalPlant – Software for bio signal viewing
    - UHF Solver – Biomedical software for ultra-high frequency ECG analysis

Specification of the contributions of the team to publications

The **contribution to the results** presented within the evaluation is in all cases a sole or a majority. In all collaborative projects the share of the department is dominant. No result is a product of any collaboration where the department might be only a small contributor.

5.2 Declaration on the involvement of students in research

Involvement of students (doctoral, undergraduate) into research

ISI CAS is not authorized to award academic titles (BSc, MSc, PhD) as such. It is however accredited as a scientific research workplace for the students of Masaryk University and Brno University of Technology. Experienced researchers at ISI CAS serve as students‘ PhD, MSc and BSc supervisors, approved by scientific boards at the respective universities. Students generally work on topics of their supervisors.

High level of the scientific work, experience of the researchers and many unique experimental instruments offer very good **opportunities** for many students.
During the evaluated period **2 Ph.D. thesis** were defended, together with **6 Master** thesis and **8 Bachelor**. This represents a **significant** involvement of students.

Particular contributions of students to research

Students are involved into the research of the department within the frame of their bachelor, master and doctoral studies. Students are **significant** contributors to all scientific outputs at ISI CAS.
In the framework of various national projects, many doctoral and undergraduate students are introduced into the joint research department. They can do very useful scientific work and help their advisors in their research tasks. Collaboration with doctoral and undergraduate students often results in publications co-authored by the students. This kind of collaboration with Universities is very beneficial for the both contracting parties.

Number of defended PhD students in relation to students involved (success rate)

For the department No 4 there were 2 successfully defended and 9 Ph.D. students have been involved in the department. The success rate of those who ended their study is **100%**, the table below includes those, who started their study in this period but did not finish it yet (they still go on studying.

Supervision of students (Department No 4)

type od study	No of supervisors	No of consultants or co-supervisors	Theses defended in 2010-2014
Bachelor	6	2	8
Master	6	0	6
Doctoral (Ph.D.)	9	0	2

Employment of former Ph.D. students (career options)

Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students are now members of the research department. The former Ph.D. students can continue their contract as so-called “post-docs”.

5.3 Declaration on societal relevance

Societal relevance of the Department of Medical signals can be seen primarily through **applied research** (collaborative and contract based) which contributes **significantly** to the **competitiveness of the national economy and health care**. The department is well established in the region as a research group with application potential and has built a network of partners with long-term collaboration. The department has developed a number of instruments and methods for medical measurement and diagnostics.

Impacts of the results and other activities on economy

The research of the department responds to actual needs of society through development of methods of effective medical treatment and diagnostics. The department tries to find the optimal targeted link between high level measurements, measurement protocols, methods of analysis and diagnostic and physiological contribution. The data acquisition and technologies, which carry additional information, is absolutely crucial. High level of the scientific work, experience of the researchers and many unique experimental instruments offer very good opportunities for university students.
During the 2010-2014 period the department was **awarded by MIT PhysioNetChallenge** Awards, in 2014 and 2015:

- •False Alarms in Intensive Care Unit Monitors: Detection of Life-threatening Arrhythmias.
- •Robust Multichannel QRS Detection.

Impacts of the results and other activities on education

The department members contribute also to teaching on various levels. Researchers participate actively in educational bachelor, master and doctoral programs mainly at Masaryk University and Brno University of Technology. The involvement of departments in student supervision is also very good.

Impacts of the results and other activities on culture

This impact should be in the field of applies physics, medicine, and technology seen through propagation and promotion of science especially of technical subjects, which is now a national priority. Popularisation of science is mentioned below.

Outputs providing information relevant for public policy decisions in all fields of life
The institute is not dealing with social sciences or humanities, so this is not relevant.

Services for research (libraries, data bases, collections,..)

The institute has a large library which can also be used by external researchers. There are various types of services for research.

Popularisation and similar activities

The Department No 4 participates (in the frame of the whole Institute) in activities of popularisation of science. There are articles in newspapers and journals (6), public lectures (3), and each year The Open Days of the ISI.
The evaluation commission judges the effort of the institute and particular departments in science popularisation as very good.

5.4 Declaration on the position in the international and national context

There is a unique expertise developed with respect to its scientific impact opens many cooperation opportunities (joint grant applications).

Comparison of the position, recognition, outputs and impacts with leading and international teams

Position of the department Medical signals in both national and international scientific community is very important. Research activities of the group have undoubtedly very important relevance not only in the national, but also in **international context** (mainly activities with The Mayo Clinic, the U.S.A.). The department Medical signals is leading in development and applications of high-tech instruments and their applications. At the moment the group activities are balanced between the fundamental research and applied research together with development.

Role and position in international collaboration

The department is well integrated into international cooperation, especially with the top medical research institution, Mayo Clinic, USA. The Further effort in identifying complementary foreign partners especially targeted on participation in international projects is recommended.

Breadth/completeness of the research activities compared to world leading teams of comparable size

The department is not easy to compare to international teams while the expertise is a unique combination of technical research, informatics and medical research and applications. At least the comparison should to their partners in international cooperation (Mayo Clinic). Seen predominantly as a team doing research in technical sciences the publication activity is not the only factor to compare performance, it has to be seen through the **whole portfolio of research outputs** including applied research, development of instrumentation, knowledge and technology transfer etc. From this point of view the outputs are good.

Ability to attract foreign researchers at different levels

The department has only 1 foreign member of the team.
It is quite common to consider teams with a large portion of foreigners as desirable. On the other hand it is questionable whether it is really an advantage or whether it is in the rich countries only a reflection of the fact that only a decreasing number of native young people are willing to do science. Here, fortunately, this problem (at least in Brno) is not so significant.

Possible missing research directions

There are no missing research directions.

Position of the team in the national context

Position of the department both national and international scientific community is very important. The department belong to leading groups at the national level with established collaborations with several teams mainly universities and hospitals. The number of research projects funded by grant agencies confirms this statement; on the other hand we cannot foresee some contractual research from hospitals.

5.5 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience

The **age structure** of this small department is of a very good distribution including students, young researchers, post docs, research fellows and senior researchers with the best qualifications reachable in the Czech Republic, which is further improved by a direct collaboration with foreign institutes (The Mayo Clinic). There were only 3 female Ph.D. students and no female permanent member of the staff. The Institute provides financial incentives to research teams successful in solicitation research funding or contractual research.

Attraction of research programmes for young people

The research programmes seem very attractive for young people. The research groups use modern methods and unique facilities. Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students, including female students, are now members of the research department. The former Ph.D. students can continue their contract as so-called "post-docs".

Funding (structure of the resources and its comparison with the outputs, grants and project activity

The **structure of funds** of the department is dominated by project funding. This introduces an **uncertainty** to the funding. A key impulse that moved the whole institute towards project funding was participation within the EU project from structural funds **ALISI**. It helped the institute to build new laboratories, purchase new, state-of-the-art equipment and hire more people.

Effectiveness of research (based on comparing size of groups, funding and output)

The output of the department in number of publications, scientific instruments, and methodologies is good or very good. Average number of about 0.5 publication/year/1FTE in journal with IF is not sufficient for a team of such a quality.

Organisational structure, recruitment methods, career system, incentives for females, young researchers, international researchers

Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students, including female students, are now members of the research department. There are new perspective and skilled researchers – Mr. Plesinger (35), Klimes (29), and

Jurco (26). Incomparable financial conditions limit significantly the possibility to attract foreign researchers including Ph.D. students from developed countries.

5.6 Declaration on the strategy and plans for the future

Relevance of the out lined strategy and research plans

Research plan of the department of Medical signals for 2015-2019 **is prepared in great detail**. Plan of the department is especially based on its human resources and budget. The department will continue in participation of existing research directions (blood circulation and hemodynamic control, heart electrophysiology, deep brain electrophysiology).
The basic policies of the department as well as the Institute will be focused mainly on institutional support of grant applications, efficient use of existing experimental equipment, and support for the rising interdisciplinary research, openness towards application of research results.

Adequacy of available means and human resources to achieve these plans

The **capabilities** of the existing research department are very good. Supplementary recruitment of researchers can be necessary maybe later. Obtaining **supplementary funding** will also be necessary.
The department wants to maintain the general organizational structure of the ISI departments, but to be flexible enough to support new scientific directions for strong individuals or projects, so that new groups can be formed. Also they want to **follow the healthy common sense** and keep a friendly and cooperative atmosphere at ISI so that everybody can enjoy the creative work.

Missing issues in the strategy

There are no missing issues, provided that the department is serious about setting up strategic **co-operations with industry and foreign research teams** with the objective of acquiring funding from EU sources.

EVALUATION OF THE INSTITUTE OF SCIENTIFIC INSTRUMENTS

Dept. of Coherence Optics

This report refers to the Evaluation of the Institute Scientific Instruments (ISI) – Department of Coherence Optics - of the Academy of Sciences of the Czech Republic, 2010-2014, and is written according the to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS. This evaluation is based on the materials provided from the Institute of Scientific Instruments and from their particular Departments, from the web pages [www.isibrno.cz], from particular presentations, and last but not least from disscussions with researchers and management of the Institute (all within the "on site visit" on October 19, 2015).

1. INTRODUCTION

There are 2 groups within the Department **Coherence Optics**
1. Group of Coherent Lasers and Interferometry,
2. Group of Laser Technology.

1.1 Location of the institute and its dept., labs. & sub units.

Laboratories and the other facilities of this department are in the main building of the Institute (Kralovopolska 147, 612 64 Brno).

1.2 Brief history of the institute (department)

The Department of Coherence Optics (former Quantum Generators of Light) was founded shortly after the invention of lasers. F. Petru was its head until 1999. In March 1963 the department had started work on the **first laser** in both solid and gaseous active media. No longer than six months later stimulated emission at a wavelength of 1.15 μm was recorded. Shortly afterwards emissions at 3.39 μm and 633 nm followed. In 1995 J. Lazar, P. Zemanek and O. Cip focused on the use of semiconductor diodes in metrology, and in particular on increasing their coherence, frequency stabilization, and interferometric systems.
[Based on materials provided and materials from www.isibrno.cz]

1.3 Mission and research topics

Involvement of the department in the Strategy of the CAS AV21

The research programme "Diagnostic Methods and Techniques" of the new Strategy AV21 includes several research topics, or sub-programmes. The Department of Coherence Optics is involved in one of them, called "Measurement methods and metrology for research and industry", which is

coordinated by Josef Lazar head of the Department of Coherence Optics, ISI and Alexander Kuna from the Institute of Photonics and Electronics.

1. Group of Coherent Lasers and Interferometry

Mission of the team:
The group **Coherent Lasers and Interferometry** is primarily involved in research dealing with **optical and laser metrology**, highly coherent lasers, interferometry, fundamental and applied (industrial) metrology and measuring techniques together with associated technology background. The **mission** of the group lies in metrology research within international context and also contributing to national metrology in cooperation with the Czech Metrology Institute and in contribution to competitiveness of Czech industry though applied research.
The field of **metrology ranges from big science (fundamental metrology) to industrial measuring techniques**. Precise measurement and sensing are very important in any industrial production, so the application potential of the research of the Department of Coherence optics is great. Researchers from the department **contributed to development of a number of industrial measuring methods and instruments**, such as nanocomparator for calibration of LVDTs, interferometric system for calibration of gauge blocks, Fiber FBG-based sensing system for strain measurement on a concrete containment, straightness measurement system for gun barrels, coordinate interferometric measuring system for e-beam writer, miniaturized fiber coupled interferometer for small-range position sensing, LIDAR-based shape scanning system for large hot forged pieces etc. The Department contributed also to national metrology through design of national standard for nanometrology and stabilized lasers – etalons of optical frequencies.

Research areas – thematic research focus:
- Optical frequency laser length standards for fundamental metrology and interferometry
- Laser interferometers and refractive index of air measurement
- Absorption gas cells for laser spectroscopy and metrology
- Femtosecond laser based optical frequency synthesis
- Special optical sensing in industrial processes and industrial measuring techniques and instruments
- Laser induced fluorescence for body fluid level measurement and tissue necrosis detection
- Electronics for process control and measurement
- Design, fabrication and employment of Fibre Bragg Grating (FBG) elements for length measurement

Excellence in the area:
- Laser length measurement with sub-nanometer resolution for nanometrology and scale-linearity testing of length sensors
- Measurement of small displacements through passive cavities with traceability through optical frequency synthesis
- High purity absorption gas cells for frequency locking of laser wavelength with stability at the level of 10^{-14} for fundamental metrology (the group supplies these optical frequency references for the whole world metrology community)
- Techniques for compensation of the refractive index of air influence with 10^{-8} accuracy in interferometry
- Contactless laser interferometry for gauge block length calibration

- Control electronics for lasers and femtosecond laser optical frequency synthesizers

2. Group of Laser Technology

Mission of the team:
The group of **Laser Technology** is dealing with high power laser technology oriented to metal welding and cutting. It combines fundamental and applied research as well, fundamental in the effort to understand the process of physical processes associated with power laser interaction with metal and applied in the development of laser welding control and welding technology for specific metals and alloys.
The **mission** of the group lies in studying of the processes in laser weld at the physical level together with mathematical modelling and statistical signal processing with an aim of application of the knowledge in the on-line control of the process and applied research contributing to competitiveness of Czech mechanical engineering industry. The group developed a **unique approach** to the welding process monitoring through spectral processing of the radiation of metal plasma plume and associated control algorithm.

Research areas – thematic research focus:
- Laser welding of various metals and alloys and metallographic analysis
- Laser 2D/3D cutting
- Laser surface hardening
- Process diagnostic through spectral analysis of plasma plume
- High power beam shaping through adaptive optics
- Design and deposition of special optical coatings for power and non-linear optics

Excellence in the area:
- Monitoring and diagnostics of laser welding process
- Adaptive control of the laser welding process

1.4 Staff size and full time equivalents age distribution

The Department No. 5 (Coherence Optics) is relatively large. The sum of the full time equivalents as of December 31, 2014
technical workers: 4.19 (6 persons)
researchers 11.83 (12 persons)

Age structure od the Team 5 [under the Institute Report]

Age	<25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	>70
number	0	6	6	1	1	2	1	0	1	0	0

Result: more than 80% of scientists of the Department of Coherence Optics have age between 25 and 50 years and about one-fourth of staff are students. Composition of the department: 2/3 engineers and 1/3 are physicists, age structure of the department is balanced (now 2 women, 2 foreigners). This department is attractive to young researchers.

2. STRENGTHS AND OPPORTUNITIES

2.1 Timeliness of research topics

The research strategy of the department is very good; it relies on cumulative building of a knowledge base through fundamental research projects and dissemination through applied research within a framework of collaborative projects with industrial partners. This concept reflects also a combination of in-depth focus and diversity of projects. Diversity seen through a large number of projects is able to deliver a flow of new ideas and impulses pushing the staff forwards. Thematic interconnection of the discrete projects through the knowledge pool generates expertise and excellence. **Large pool of knowledge, experience and technology background** can be seen through a **number of excellent** results in both fundamental and applied research.

2.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The department is **fully project funded** (including all salaries of the staff) so it has to rely on a large number of diverse projects. There are two key projects (Center of Excellence – fundamental research, and Center of Competence – applied research) that represent the core funding. This diversity can be also seen as a threat. On the other hand it is a great success and strength of the Department that has been able to **succeed** in numerous project applications and it is an opportunity to the future that with this skill it will be able to succeed in further projects and grants.
The ability of the department researchers (primarily the senior researchers) to keep the department project funded is a result of **huge effort and determination unprecedented** in the whole Czech Academy of Sciences. The department of ca **20 people** is involved in solution of about **15 projects** at once.

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

Position of the department both national and international scientific community is very important. The department is and has been participating on **three international projects** over the last five years. The position within the European research environment is now well established and negotiations on participation on next international collaborative projects are on the way.
Two of these international projects were targeted to metrology: **6DoF** and **SIB60 Surveying;** and confirm **inclusion** of the department into the international metrology community. The project **HiPER** (High Power laser Energy Research facility, now postponed) involved the Group of Laser Technology and deposition of special coatings for high power laser amplifiers.

2.4 Position of the institute within the Czech scientific community and its international position

Wide, long-term, and very well built **network of cooperation** with universities, hospitals and companies. Due to its multidisciplinary orientation on methodologies, the department **efficiently** cooperates with the whole portfolio of end-users for the research. A rich history of collaborative research of the department directs predominantly towards universities in Brno, particularly the Technical University and to the Czech Metrology Institute. The contract research is often targeted abroad (metrology community), so the link to application partners abroad is also very strong.

2.5 The overall capacity of staff

The gradual build-up of the staff of the Department of Coherence optics is a result of long-term strategy to put together engineers and physicists, specialists in various fields, such as: analog electronics, digital electronics, optics, mechanics, software, thin films, materials, spectroscopy, laser physics, data processing, mathematics, etc., constituting very good **multidisciplinary team** able to address a large variety of problems.

2.6 Comments on the age structure

The age structure is very well **balanced**, with a majority of young and motivated people. More than 80% of scientists of the Department of Coherence optics have age between 25 and 50 years and about one-fourth of staff are students; reasonable number of staff, low fluctuation of employees and single location ensure that the employees and management know each other personally for reasonably long time to build very efficient way of cooperation and communication.

2.7 Frequency and quality of publications

Publishing activities per are not of a large quantity, but high quality**.** Frequency of publications is adequate to the specific field of "Instruments and instrumentation research". Scientometric studies comparing domestic and international quality and amount of publications within narrow research specializations have shown that this publication activity is well comparable with the European standard. During the 2010-2014 period, there were published papers in journals with IF (25 in total), papers in other journals (12 pieces), and papers at conferences (170). There were 199 applied results. In the Evaluation Phase I, 2 selected publications were classified as world-leading, 8 as internationally excellent, and 5 as internationally recognized. This shows that the quality of the publications is very good and the department is **concentrating on quality** of the publications, not quantity.
More, publications in technical sciences represent only a part of the outputs. The **overall outputs** of the department seen together with applied research, knowledge and technology transfer, dissemination of the results and contribution to the competitiveness of national economy must be judged as very good.

Department of Coherence Optics – results during the period 2010 – 2015

	Team of Coherence Optics
Papers in journals with IF	25
Papers in other journals	12
Scientific books	0
Papers at conferences	170
Patents	6
Applied results	199
Number of scientists	10.00
Number of other workers in department	3.16

2.8 Patents and role in contractual work

During the 2010-2014 period **9 patents** were supplied by the department. Contractual work is a source of **significant** incomes. The role of the Team/Institute on contractual work is generally not related to patents but in the solution of practical problems. The amount of time and resources coming to contractual research is limited with respect of the other source of budget.

3. WEAKNESSES AND THREATS

3.1 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The department is **fully project funded.** It is a product of the research environment in the Czech Republic with a large portion of purpose (project funding). Still, all projects are interlinked though the core pool of knowledge of the department and constitute an interconnected network of research effort making the diversity more or less virtual. On the other hand the diverse project funding pushes the key researchers to spend enormous time searching for funding sources, writing project proposals and wasting time with project agenda. The low success rate of project calls make it even worse and rising vulnerability. A key impulse that moved the whole institute towards project funding was participation within the EU project from structural funds **ALISI**. It helped the institute to build new laboratories, purchase new, state-of-the-art equipment and hire more people.
The Comment of the Commission: The department as well as the whole Institute would prefer a larger part of the funding provided directly by the Academy of Sciences, without competition. The evaluation commission understands that it would be much more comfortable for the institute to have a larger amount of non-competitive funding. It can support the stability of the research department from the point of view of staff and research directions.
A threat, to which most research teams in western and middle Europe are confronted with, including the Institute of Scientific Instruments, is the tendency for reduction of the funding possibilities on the national level and thus continue involvement in projects with EU funding or international funding. The institute is fully aware of this necessity. The Department of Coherence Optics has succeeded in participating in several EU projects. Clearly, continued efforts in trying to participate in EU projects are necessary.

3.2 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

The staff is only partially international. The department includes two foreign researchers – this number reflects on one hand a limited chance to attract foreigners from richer countries while keeping acceptable social balance between foreigners and Czechs at the corresponding level of work productivity and on the other hand still persisting will of native young people to do science. This, fortunately, makes this problem (at least in Brno) is not so significant.

4. RECOMMENDATIONS

4.1 Re-organization of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

At the moment we **do not recommend** some type of re-organization of the internal structure of the Department No 5. It must be prepared to solve new research topics in future. For these purposes it is desirable to looking for other adequate personal and financial sources in the future.

4.2 Internal programs to stimulate actions to enforce strengths and to reduce weaknesses

Within the Institute they have various programs to enforce strengths and to reduce weaknesses. Emphasis is on contributions in high quality journals. There are internal programs and incentives to stimulate a conversion of results from conference contributions into regular journal articles. Focus on strengthening of international collaboration. The teams are under the supervision The Director and The Council.

4.3 Identification of new research topics

The research plan of the whole institute (for 2015–2019) sets the main goal to utilize researches' intellectual potential and up-to-date equipment and enhance existing methods of investigation of nanoworld, microworld and macroworld in the relevant areas of physics, biology, medicine and engineering. There does not seem a direct need to search for another new research topics. These come spontaneously. Relevance of the plans is limited by funded grants and projects.
The **most important trends** within the group of Coherence Optics are as follows:

- Transfer of highly stable optical frequencies over long distances in optical fibres
- Optimization of sensing networks using fibre-Bragg-gratings
- Filtering of optical spectrum of frequency comb with passive optical resonator (in cooperation with TU Delft)
- Completion of the family of interferometric systems and their transfer into production (in cooperation with Meopta-optika)
- Improvement of monitoring methods and controlling processes of laser welding
- Experimental research with trapped Ca ions (with Palacky University in Olomouc)
- Development of metrology-grade electron microscope (with EM producer)
- Measurement of special structures and shapes using interferometry involving non-Gaussian beams and adaptive optics

5. DETAILED EVALUATION

5.1 Declaration on the quality of the results and share in their acquisition

Characterisation of the main research activities (experiments, theoretical areas)

The main research activities of the Team have **very complex** character and they include both theoretical approaches and sophisticated experimental research. Main results can be shortly divided into two groups, reflecting the division of the Team into two groups.

Relevance in the national and international context

The effort of the department resulted in a number of high quality results in both fundamental and applied research. The results were achieved within the framework of Czech research projects,

international projects, and international cooperation. The activities of the department fit into international context of metrology and laser technology research, is **well internationally integrated**. The department is unique with respect to complete expertise in lasers, interferometric systems, and laser welding. It is successful in many national project applications.

Overall quality of publications

Publications in technical sciences represent only a part of the outputs. The **overall outputs** of the department seen together with applied research, knowledge and technology transfer, dissemination of the results and contribution to the competitiveness of national economy must be judged as very good in **quantity and quality**.

The results from evaluation phase I shows that the quality of the publications is very good and the department is **concentrating on quality** of the publications, not quantity. The majority of evaluated publications belongs to internationally (10) and nationally recognized outputs (5). Among world-leading publications there are 2 papers. One papers are published in top decile (1*) and quartiles 1-2 by AIS of journals (1 + 16). These facts were confirmed in the Evaluation Phase I. Also intensity of citations of these publications is on average level.

During the evaluation period, there were the following **awards** given:

- Gold Medal 2012 International Engineering Fair
- Siemens Excellence Award 2012 for System with automated control for Gauge blocks contact-less calibration.

Specification of the main achievements

Thanks to a diversity of research topics over the specified period the main achievements can be presented as the results of the numerous research projects in a following short overview:

- optical frequency synthesis with a technique of locking of a mechanical standard – an etalon – to a highly stable optical frequency comb component selected by optical filtering of frequency components by a fibre Bragg grating
- investigation of quantum mechanics with trapped ions, especially Calcium ions with the goal of development of optical ultra-stable laser oscillators
- technology of time and frequency transfer through long haul optical networks
- introduction of a novel method of contactless gauge blocks calibration and diagnostics combining Michelson interferometer and a white light Dowell interferometer
- new displacement measurement principle based on referencing of wavelength of the coherent laser source in atmospheric conditions instead of traditional stabilization of the optical frequency and thus compensating for changes of refractive index of air
- direct transfer of displacement on the nanometre level into frequency where the technique works as a generator of precise length displacement.
- a new technique of the evaluation of the phase of the interference signal in displacement interferometry using a digital derivative technique
- experimental setup for filtering of selected components of optical frequency comb using a passive optical cavity

- development and design of a nanometrology measuring system which is a part of the national standard for nanometrology operated by the Czech Metrology Institute
- positioning systems combined with high-precision measurement of the displacement for medium-range coordinate dimensional metrology
- modular family of components configurable for various arrangements primarily for multi-axis coordinate measurements in nanotechnology and surface inspection
- coordinate interferometric measuring systems for an e-beam writer in collaboration with company Tescan in Brno
- development of stabilized semiconductor laser sources suitable for interferometry stabilization together with pairs of laser diodes stabilized to constant beat frequency
- monitoring of the deformations of shape of a containment building in nuclear power plant in Temelín via a set of FBG strain sensors.
- the Department of Coherence Optics established itself as a dominant and much respected supplier of the best quality references – absorption cells in the metrology community
- discovery that the properties of the frequency spectrum of radiation of the plasma plume generated by the laser welding process depends on the weld depth
- a control algorithm that adjusts on-line the position of the focal point and controls the welding process to achieve high-quality laser weld with constant parameters

Specification of the contributions of the team to publications

The **contribution to the results** presented within the evaluation is in all cases a sole or a majority. In all collaborative projects the share of the department is dominant. No result is a product of any collaboration where the department might be only a small contributor.

5.2 Declaration on the involvement of students in research

Involvement of students (doctoral, undergraduate) into research

ISI CAS is not authorized to award academic titles (BSc, MSc, PhD) as such. It is however accredited as a scientific research workplace for the students of Masaryk University and Brno University of Technology. Experienced researchers at ISI CAS serve as students‘ PhD, MSc and BSc supervisors, approved by scientific boards at the respective universities. Students generally work on topics of their supervisors.
High level of the scientific work, experience of the researchers and many unique experimental instruments offer very good **opportunities** for many students.
During the evaluated period **11 Ph.D. thesis** were defended, together with **23 Master** thesis and **12 Bachelor**. This represents a **massive** involvement of students. The department has **1 professor, 1 associated professor** and three other scientists entitled to supervise Ph.D. thesis by the Science board of the Technical University in Brno.

Particular contributions of students to research

Students are involved into the research of the department within the frame of their bachelor, master and doctoral studies. Students are **significant** contributors to all scientific outputs at ISI CAS.
In the framework of various national projects, many doctoral and undergraduate students are introduced into the joint research team. They can do very useful scientific work and help their advisors in their research tasks. Collaboration with doctoral and undergraduate students often results in publications co-authored by the students. This kind of collaboration with Universities is very beneficial for the both contracting parties.

Number of defended PhD students in relation to students involved (success rate)

For the Department No 5 there were 11 successfully defended. This shows a success rate was about 70 %, but this number is distorted by the fact, that the number of 15 Ph.D. students include those, who started their study in this period but did not finish it yet (they stil go on studying. In the historical perspective all Ph.D. students in this department completed successfully their study. This represents **100% success rate**. Hopefully those, who do their study now will finish it as well and the full success rate will stay.

Supervision of students (Team No 5)

type of study	No of supervisors	No of consultants or co-supervisors	Theses defended in 2010-2014
Bachelor	12	2	12
Master	31	3	23
Doctoral (Ph.D.)	15	2	11

Employment of former Ph.D. students (career options)

Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students, including female students, are now members of the research department. The former Ph.D. students can continue their contract as so-called "post-docs". The possibility to open new positions for postdocs within the teams of the department is given by the **successes in grants** and projects which provide funding for them.

5.3 Declaration on societal relevance

Societal relevance of the Department of Coherence optics can be seen primarily through **applied research** (collaborative and contract based) which **contributes significantly** to the **competitiveness of the national economy**. The department is well established in the region as a research group with application potential and has built a network of partners with long-term collaboration. The department has developed a number of instruments and methods for industrial measurement and also contributed to national fundamental metrology through design of national standards.

Impacts of the results and other activities on economy

As stated above, the department follows a concept of balanced combination of **fundamental and applied research**. The strategy has been described as core knowledge/technology/experience base vs.

project diversity. Many of the diverse projects target specific applied research problems. Thanks to this concept the department has a **broad collaboration** with the industry and participates on solving of manufacturing problems of industrial partners (sometimes involving also other research institutes and universities) within the frame of collaborative and contractual research. The department as well as the whole ISI created a network of long-term collaborative partnerships, a result of confidence building with industry. The **contribution to the competitiveness** of the Czech industry through applied research is excellent.

During the 2010-2014 period, the following awards were grated for excellent results in applied research in collaboration with Czech industrial partners:

- Gold Medal 2012 International Engineering Fair
- Siemens Excellence Award 2012

for System with automated control for Gauge blocks contact-less calibration.

Research activities and their results have very strong impact on the Institute economy as well, both income from grants and projects supports the budget which depends on the quantity and quality of the outputs.

Impacts of the results and other activities on education

High level of the scientific work, experience of the researchers and many unique experimental instruments offer very good opportunities for many students. The department has **1 professor, 1 associated professor** and three other scientists entitled to supervise Ph.D. thesis by the Science board of the Technical University in Brno. The staff contributes also to teaching on various levels. Researchers participate actively in educational bachelor, master and doctoral programs mainly at Masaryk University, Palacky University, and Brno University of Technology. The involvement of Teams in student supervision is also very good.

Impacts of the results and other activities on culture

This impact should be in the field of applies physics and technology seen through propagation and promotion of science especially of technical subjects, which is now a national priority. Popularisation of science is mentioned below.

Outputs providing information relevant for public policy decisions in all fields of life

The institute is not dealing with social sciences or humanities, so this is not relevant.

Services for research (libraries, data bases, collections,..)

The institute has a large library which can also be used by external researchers. There are various types of services for research.

Popularisation and similar activities

The Department No 5 participates (in the frame of the whole Institute) in activities of popularisation of science. There are contributions to local radio broadcast (3), articles in newspapers (2), presentations

for general public (10), laser shows (2), each year: Week of Science and Technology of the CAS, Visitor‘s Days of the ISI, and the Festival of Science in Brno. The head of the department, Josef Lazar has been a **coordinator of a large popularization project** called "Science Academy", in cooperation with the Science Center in Brno, Brno Observatory and Planetarium. The evaluation commission judges the effort of the institute and particular teams in science popularisation as very good.

5.4 Declaration on the position in the international and national context

There is a unique expertise developed with respect to its scientific impact opens many cooperation opportunities (joint grant applications).

Comparison of the position, recognition, outputs and impacts with leading and international teams

Position of the group Coherence Optics in both national and international scientific community is very important. Research activities of the group have undoubtedly significant relevance not only in the national, but also in international context. The group Coherence Optics is **leading in development and applications of high-tech instruments**, their applications, and methodology oriented research in metrology.
The department established its position among research oriented metrology institutions. It participates in international metrology projects with leading European metrology institutes and plays a role of a reliable and useful partner doing very good and respected research which is **internationally recognized and appreciated**.

Role and position in international collaboration

The department is and has been participating on **three international projects** over the last five years. The position within the European research environment is now **well established** and negotiations on participation on next international collaborative projects are on the way. Two of the projects were targeted to metrology: **6DoF** and **SIB60 Surveying;** and confirm **inclusion** of the department into the international metrology community. The project **HiPER** (High Power laser Energy Research facility, now postponed) involved the Group of Laser Technology and deposition of special coatings for high power laser amplifiers.
Especially contract research for international metrology institutions oriented on development of **optical frequency references** helped the department to gain great international renown and recognition in the metrology community. With some exaggeration the whole **world length metrology relies on the references** from Department if Coherence optics, ISI.

Breadth/completeness of the research activities compared to world leading teams of comparable size

The department should be compared to the best European research oriented metrology institutions, like PTB Germany, NPL Great Britain, METAS Switzerland, LNE France and others. In metrology the publication activity is not seen as the key factor to compare performance, it has to be seen through

the **whole portfolio of research outputs** including applied research, development of instrumentation, knowledge and technology transfer etc. From this point of view the outputs are very good.

Ability to attract foreign researchers at different levels

The Department of Coherence Optics includes **2 foreign members** which is **a** good number for the standards of the Institute (and Brno as well). This has been achieved even without any support by any project of scientific mobility.
It is quite common to consider teams with a large portion of foreigners as desirable. On the other hand it is questionable whether it is really an advantage or whether it is in the rich countries only a reflection of the fact that only a decreasing number of native young people are willing to do science. Here, fortunately, this problem (at least in Brno) is not so significant.

Possible missing research directions

There are no missing research directions.

Position of the team in the national context

Position of the Team both national and international scientific community is very important. The Team belongs to leading groups at the national level with established collaborations with several Czech teams mainly at universities. The number of contractual research and collaborative research projects funded by grant agencies confirms this statement.

5.5 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience

The **age structure** of this big department is of a very good distribution including students, young researchers, post docs, research fellows and senior researchers with the best qualifications reachable in the Czech Republic, which is further improved by a direct collaboration with foreign institutes. The department also includes **2 foreign** researchers and **2 female** researchers (and 2 technicians).
The Institute provides financial incentives to research teams successful in solicitation research funding or contractual research.

Attraction of research programmes for young people

The research programmes seem very attractive for young people. The research groups use modern methods and unique facilities. Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students, including female students, are now members of the research department. The former Ph.D. students can continue their contract as so-called “post-docs”.

Funding (structure of the resources and its comparison with the outputs, grants and

project activity

The **structure of funds** of the department is strongly **dominated by project funding**. In fact all salaries are covered by projects with no (or negligible) contribution from the institutional funding. The dominant project funding is a reality for the department for the whole evaluation period where institutional support has been negligible or zero. Small contribution is represented by contractual research. A key impulse that moved the whole institute towards project funding was participation within the EU project from structural funds **ALISI**. It helped the institute to build new laboratories, purchase new, state-of-the-art equipment and hire more people.
The ability of the department researchers (primarily the senior researchers) to keep the department project funded is a result of **huge effort and determination, unprecedented** in the whole Czech Academy of Sciences.

Effectiveness of research (based on comparing size of groups, funding and output)

The output of the department seen through the number of overall outputs, including publications, their quality, development of instrumentation and technologies, methodologies and applied research is very good. In technology oriented research the efficiency should be judged also through societal impact on the economy, which is very good (see above).

Organisational structure, recruitment methods, career system, incentives for females, young researchers, international researchers

Recruitment possibilities by the department and career possibilities of former Ph.D. students are very good. Several former students, including female students, are now members of the research department. The former Ph.D. students can continue their contract as so-called "post-docs". The chance for postdocs to become members of the team is given by the ability of the department researchers (primarily the senior researchers) to succeed in project proposals and to keep the department **project funded** and **open new positions** as a result of huge effort**.**

5.6 Declaration on the strategy and plans for the future

Relevance of the out lined strategy and research plans

Research plan of the Department of Coherence Optics for 2015-2019 **is prepared in great detail**. Plan of the department is especially based on its human resources and budget. The department will continue in participation of existing two directions. The basic policies of the department as well as the Institute will be focused mainly on institutional support of grant applications, efficient use of existing experimental equipment, and support for the rising interdisciplinary research, openness towards commercialization of research results.

Adequacy of available means and human resources to achieve these plans

The **capabilities** of the existing research department are very good. Supplementary recruitment of researchers can be necessary maybe later. Obtaining **supplementary funding** will also be necessary.
The department wants to maintain the general organizational structure of the ISI departments, but to be flexible enough to support new scientific directions for strong individuals or projects, so that new groups can be formed. Also they want to **follow the healthy common sense** and keep a friendly and cooperative atmosphere at ISI so that everybody can enjoy the creative work.

Missing issues in the strategy

There are no missing issues, provided that the department is serious about setting up strategic **co-operations with industry and foreign research teams** with the objective of acquiring funding from EU sources.

Date: January 20, 2016

Commission Chair: em Prof.DI.Dr.Dr.hc. Hans Peter Nachtnebel