Final Report Summary - BY-NANOERA (Institutional Development of Applied Nanoelectromagnetics: Belarus in ERA Widening)

Executive Summary:

The main result of the project is essential reinforcement of the cooperation capacities of the Institute for Nuclear Problems, Belarusian State University (INP BSU) in ERA through the institutional development of the new research discipline – applied nanoelectromagnetics (NEM). A contribution into RTD capacity in Belarus has been done through the development of scientific foundation of the nanoelectromagnetics as a novel interdisciplinary trend comprising classical electrodynamics and present-day condensed matter physics, and laying the applied nanoelectromagnetics as a RTD tool. The NEM Prognosis has been worked out and published in Russian (hard copy) and English (on-line version). Based on the NEM Prognosis and taking into account socio-economical needs and trends both in Belarus and EU, the strategy of INP BSU as a focus institution for applied nanoelectromagnetics has been developed. On the national level, Strategy orients INP BSU on active work within national RTD programs aiming at setting up and developing of nanoindustry in Belarus till 2020. On international level, the Strategy implies synchronization with the EU policy in nanoscience and nanotechnology, participation in EU INCO programs, international cooperation widening, support of young scientists careers through the mobility and knowledge exchange strengthening.

The later goal is also achieved through training courses organized within the project. These courses were directed to the INP BSU’s competence building and facilitating its participation in EU INCO programs and attracted significant interest not only in BSU but also among young scientists from other Belarus research institutions. As a result of the strategy dedicated realization, the fundamental and applied nanoelectromagnetics has been incorporated into Belarus research area and is currently considered as a topic corresponding to priorities in the national RTD strategy. INP BSU successful experience in the INCO activity disseminated through different channels gives motivation and roadmap for other Belarus small- and middle-scale research teams for incorporation into ERA trough proposals submission to FP7/"Horizon 2020" Calls and other INCO programs.

A set of scientific events devoted to nanoelectromagnetics have been organized in Belarus and abroad, such special Nanoelectromagnetics sections at Nanomeetings (2011 and 2013, Minsk, Belarus) and International conference on Electromagnetics in Advanced Applications (2012 and 2013, Torino, Italy). The central event from this set was the international conference "Fundamental and Applied Nanoelectromagnetics" (FANEM, BSU, Minsk, Belarus, May 2012) which have attracted about 120 researchers from 19 countries specializing in the electromagnetic theory and applied electromagnetics as well as in different areas of the nanoparticles and nanostructured materials physics, chemistry and applications. The conference provided a forum to both stimulate the development of nanoelectromagnetics and introduce the language and the problems of the present-day electromagnetics and photonics to the nano-materials research community. A special section of the Journal of Nanophotonics (SPIE) “Fundamental and Applied Nanoelectromagnetics” has been published in the second half of 2012.

The interdisciplinary character of scientific problems covered by NEM resulted in establishing long-term cooperation within the
project consortium and attracted new members into the cooperation network. More than 50 research papers have been published in peer-reviewed journals in the field of NEM, and many invited and regular talks have been delivered at different scientific events. During the project realization, a set of submission to EU FP7 have been done both in collaboration with the consortium members and with newly-found partners resulting in approve and start of several NEM projects. At the output of the project one can state the appearance in Belarus a highly qualified research unit comprising both internationally recognizable experts and well-motivated young researches in the field of science and application of nanostructures and, in particular, in NEM. The team actively participates in national research activity and is competitive on the international level to provide significant contribution into both national and international RTD programs.

Project Context and Objectives:

As a principal goal, the project implies

Reinforcement of the cooperation capacities of INP BSU in ERA through the institutional development of the new research discipline – applied nanoelectromagnetics.

On this way, a set of coupled tasks were solved:

- To prove necessity and promising capability of nanoelectromagnetics in the core objective of FP7 Theme 4 ‘Nanosciences, Nanotechnologies, Materials and new Production Technologies – NMP’ and to develop a concept of nanoelectromagnetics as a perspective direction in NMP.
- To develop the strategy of INP BSU as a focus institution for the applied nanoelectromagnetics evolution on the national and European levels;
- To establish network with research centers in Member States or Associated Countries in the field of applied nanoelectromagnetics aimed with the progress in solving concrete scientific problems and submission of joint research projects.
- To develop training modules to build competency and facilitate the participation in FP7 of INP BSU;
- To organize a set of workshops and seminars on nanoelectromagnetics;

To propose the reinforcement scheme developed for INP BSU as a model for the Belarus teams’ incorporation into European Research Area.

In accordance with the stated tasks the project work program has been grouped into four Work Packages.

Work package: 1. Framing and supporting the INP BSU’s research activities and institutional development in NEM

The main objectives of this work package are

- To define the prospective areas of NEM implementation in ERA and to develop a prognosis of the NEM development;
- To work out the INP BSU’s long-term Strategy of development in the area of NEM.
- To develop tools and materials for promotion of the INP BSU’s potential

The WP1 has been broken into three tasks:

Task 1.1 Developing a Prognosis of NEM development and practical implementation

The expert group has been created for elaborating a Prognosis of NEM development and practical implementation. The expert group comprises representatives of the partner organizations INP BSU, TUB and INFN, as well as external experts: P.
A Prognosis of the NEM development has been worked out and presented at FANEM'12 (International Conference “Fundamental and applied nanoelectromagnetics”, BSU, Minsk, Belarus, May 22-25, 2012); a Russian-language draft of the Prognosis has been published by the Belarus State University Publishers and is widely disseminated in Russian-language nanocommunity in both Belarus and Russia. English version of the Prognosis has been presented (and is planned for further dissemination) in a set of international meetings organized by the consortium and is on-line available at the Project website (D1.3 from WT2: List of Deliverables). As Prognosis impact on the national level, the INP BSU enter the State R&amp;D Program “Convergence” under the Project 3.4.01.1 “Development and implementation, on the base of the new research discipline “Applied nanoelectromagnetics”, of the national interdisciplinary platform on modeling, study and application of electromagnetic properties and processes in nanostructured objects and systems”. A set of lectures under umbrella title "Challenges and Perspectives in Nanoscale Electromagnetics" has been given at institutions seminars (University of Cassino and University of Salerno, Italy, University of Latvia, Defense Institute of Advanced Technology, Pune, India, Harbin institute of Technology, China, Weizmann institute of Science and Tel Aviv University, Israel, etc.) or has been presented as invited talk at international conferences.

Task 1.2 Working out a Strategy of INP BSU’s long-term development in the area of NEM

A working group has been created for elaborating the INP Strategy in the field of nanoelectromagnetics. The group was formed by Belarusian scientists from BSU, National Academy of Sciences and comprises an advisory board of EU team leaders of BY-NANOERA. A concept of the Strategy has been presented and discussed at the Policy Stakeholder Conference on “EU-EECA Cooperation in Research and Innovation: The way towards 2020” (Warsaw, Poland 15-16/11/2011, www.policystakeholders2011.pl). : S.A. Maksimenko, “The role of the EU research and innovation programs in the surviving strategy of small and mid-size research team". A strong feedback to the INP Strategy has been given by the Benchmarking of the European, Eastern European and Central Asian RTDI Institutions from the field of Nano- Science/Nano-Technology, carried out in the frame of the project IncoNet EECA (http://www.inco-eeeca.net/) and, in particular, by European experts (Prof. Erich Gornik and Dr. Elke Dall, Austria, Dr. Paul Tomlins, UK) visiting INP BSU in April 2012.

The Strategy is based on detail SWOT analysis and its recommendations and formulates very ambitious goal: By 2025, the INP BSU will become a center of excellence in Nanoelectromagnetics benefiting from its leading position in Belarus nanoscience and nanotechnology community and complete integration in the European Research Area. In alliance with the Belarusian State University, it will be an important center of nanoscience education and innovations in Belarus and Eastern Europe.

The Strategy states several long-term goals

1. To provide R&amp;D support for breakthrough projects in NEM, as well as bridging the gap between research and innovation within the main priorities: electromagnetic compatibility on nano scale (nanoEMC), nanocarbon based CNT devices and materials, radiation protective materials and technologies, solar energy, nanoscience and nanotechnology education.

2. To ensure sufficient and stable financing for the INP BSU research and innovation activities on the base of multi-vector research policy which primarily should be oriented on national science and innovation market but also should be worth to attract international funds, both European and Asian (China, India, South Korea, etc).

3. To sustain a highly qualified and motivated core team working in close contact with the host University. The internal institute policy should ensure each member of the INP BSU team benefits from participation in international projects in terms of international mobility, acquiring new skills and best practices, exchanging results, publicizing and disseminating, and, jointly with the host university, should be oriented to get into specialized international projects on professional training of young
researchers in nanosciences.

4. To improve the INP BSU research infrastructure comprising effective exploitation of equipment available at the university centers of collective use, formation of own research equipment park, and extension of inter-institutional cooperation, both on national and international levels.

Task 1.3 Promoting INP BSU’s potential for facilitating its participation in the FP and other INCO programs

The activity on promoting INP BSU’s research capacity and potential for international collaboration was (and is) implemented from the very beginning of the project. As examples,

- A special talk "Presentation of new EU projects FP7-247007 CACOMEL and FP7-266529 BY-NanoERA" has been delivered by S. Maksimenko at The 2nd International Workshop on Nanocarbon Photonics and Optoelectronics, Koli/North Karelia/Finland, 1-6 August 2010
- The Nanoelectromagnetics portal [http://www.nano.bsu.by/](http://www.nano.bsu.by/) has been created which includes the BY-NanoERA Website. (D1.1 from WT2: List of Deliverables)
- Four INP BSU participants of BY-NANOERA, K. Batrakov, P. Kuzhir, G. Slepyan and S. Maksimenko, have been awarded (October 2011) by the highest BSU award for achievements in natural sciences - the Belarusian State University Award named by Academician A.N. Sevchenko - for the work “Electromagnetics of nanostructures”. This Award serves as a successful story for Belarusian teams seeking the development strategy.
- A special section of the Journal of Nanophotonics (SPIE) “Fundamental and Applied Nanoelectromagnetics” has been published in the second half of 2012

FP7 infoday has been organized in Minsk, Belarus, October 19, 2011

- A set of promoting materials has been prepared and published. (D1.2 from WT2: List of Deliverables)
- Promoting materials and special promoting talks were delivered at all scientific events organized by the consortium

Work package: 2. Facilitating INP BSU’s research potential, information exchange and identifying partners

The main objectives of this work package are:

- Realization of the staff visiting program as a supporting action directed to the progress in key scientific problems of NEM.
- Organization of a number of international scientific conferences (sections at conferences), seminars and participation of INP BSU staff in FP7 events
- Training of young researchers in the area of NEM for ensuring high quality and sustainability of INP BSU’s personnel

The WP2 has been broken into four tasks:

Task 2.1 INP BSU staff visit program for joint R&D activities, information and experience exchange

Staff visiting programs have been developed for 2011 - 2013 and used for the visits management; About 20 month training visits from INP BSU to partners took place as well as about 30 visits abroad to international conferences. The visits results in activation of collaborative research in solving concrete scientific problems related to nanoelectromagnetics (see Task 2.1 of the Description).

51 joint papers have been published in international peer-reviewed journals and about 60 talks (including 10 invited presentations) has been delivered at international scientific conferences. Several papers are accepted for publication where
the BY-NANOERA support is acknowledged.

Tasks 2.2 and 2.3 Organizing joint scientific events (workshops, conferences, etc) in Belarus and abroad; Participation in INCO events in EU MS and AC.

Eight special sessions have been organized under the direct support of BY-NANOERA at different international conferences, and 6 of them in EU countries. The central event of the project was The International conference "Fundamental and Applied NanoElectroMagnetics" FANEM'12, May 22-25, 2012, Belarusian State University, Minsk, Belarus, [http://www.nano.bsu.by/](http://www.nano.bsu.by/). The project coordinator Prof. S. Maksimenko entered the Organizing or Program Committees of 8 scientific conferences. INP BSU participated in a set of FP7 INCO events, such as

- FP7 infoday, Minsk, Belarus, October 19, 2011
- The Benchmarking of the European, Eastern European and Central Asian RTDI Institutions from the field of Nano-Science/Nano-Technology, carried out in the frame of the project IncoNet EECA ([http://www.inco-eeca.net/](http://www.inco-eeca.net/))

The second edition of the International conference "Fundamental and Applied NanoElectroMagnetics" FANEM'14 is planned to be held in June 2014 in Minsk subject to support from NATO ARW program. Application is under evaluation. Positive decision has been made National Research Foundation of Korea on the financial support of Korea-Belarus workshop in Minsk on nanoscience with Prof. Maksimenko as chairman. The event will be joined with FANEM'14 in the case of the NATO ARW application success.

Task 2.4 Identifying partners, setting up consortium and preparing applications for FP7/FP8 calls and other INCO programs for proposals in NMP

New collaborative links and new project consortia have been established as a part of BY-NanoERA activity, which includes research institutions from AC and MS: Armenia, Belgium, France, Italia, Latvia, Lithuania, Russia, Ukraine. A set of collaborative projects in the area of applied nanoelectromagnetics has been submitted and approved. The set includes bilateral projects with FSU and neighboring countries (Latvia, Ukraine, Armenia, Russia) and three EU FP7 projects: FP7- 318617 FAEMCAR, FP7-612285 CANTOR, : FP7-610875 NAMICEMC. NATO Science for Peace project is under evaluation and Graphene Flagship project is currently under preparation.

Work package: 3. Training for INP BSU’s competence building and facilitating its participation in FP7

The main objective of this work package is to enhance participation of INP BSU in the activities of FP7 via special staff training. Several consecutive actions have been carried out:

- Examining the training needs and developing a program of trainings for different groups of researchers from INP BSU, BSU and other research organizations
- Developing the 3 training modules on different aspects of the FP7
- Organizing and conducting 3 trainings
- Consulting INP BSU staff during setting up of consortia and at the proposal preparation stages.

Additional consulting has been organized and is implemented because of the Horizon 2020 start. During the training courses and in presentation in Belarus mass media (which were especially active in the time of FANEM conference), the reinforcement scheme developed for INP BSU was actively presented as a EU-Belarus link in fast developing research area and as a model for the Belarus teams’ incorporation into European Research Area.
Work package: 4. Management

The main objectives of this work package are
• To organize and coordinate the entire flow of activities, in such way as to meet the project objectives
• To ensure the proper implementation of the contract (reporting, administration, costs statements)

The WP4 has been broken into three tasks:

Task 4.1 Organizing and carrying out Consortium meetings

During the project there have been 4 Consortium meetings:

Kick-off meeting in TU Berlin, January 17 2011. Project coordinator, all EU countries team leaders (except Bulgarian) and EC project officer have been presented. TU Berlin as the host institution has been chosen because of dense traveling schedule of participants.

Consortium meeting at the International workshop Nanoscience and Nanotechnology Nbrush N&N11, INFN, September 19 – 23, 2011. Project coordinator and all EU countries team leaders have been presented. Prognosis group meeting was also organized during the conference.

Consortium meeting at the International conference "Fundamental and Applied NanoElectroMagnetics" FANEM'12, May 22-25, 2012, Belarusian State University, Minsk, Belarus. Project coordinator and all EU countries team leaders have been presented.

Closing meeting in INP BSU, Minsk, October 18-24, 2013. Project coordinator and all EU countries team leaders (except Germany) have been presented. The main topic of the meeting was discussion of different ways for prolongation of established collaborative scheme. since the topic is much wider the BY-NANOERA consortium, newly established collaborators were also invited (group leaders from Belgium, Hungary, Ukraine, Lithuania, Russia)

Task 4.2 Organizing and carrying out Management Board meetings

during reporting period all teams leaders (Management Board) were in direct contact with project coordinator and between each other by e-mail, Skype and, often, phone. Also, visits and participation in scientific events have been used for meetings and discussions of the project management.

Task 4.3 Administration of the contract

Services and submitting the required Activities and Management reports have been carried out.

Project Results:

As a principal goal, the project implies:

Reinforcement of the cooperation capacities of INP BSU in ERA through the institutional development of the new research discipline – applied nanoelectromagnetics.

The BY-NanoERA focus team (basically, it’s the staff of the Laboratory of Electrodynamics of Nonhomogeneous Media, INP BSU) consists of about 20 researchers, including two doctors of science, five leading researchers, two chief researchers,
technicians and a significant number of PhD students. The basic structure is balanced between the different age groups and has a potential to be sustainable. The number of PhD students and young researchers is sufficient to make significant progress on national and international projects, mainly but not exclusively funded by the EU throughout the FP7 and ISTC. With the termination of the ISTC activities due to the decision of Russia and, later on, Belarus to withdraw, the FP7 remains the only instrument funding large international multi-lateral R&D projects which the INP BSU, as well as other Belarusian research centers, can take part in as legal entities.

Currently, the INP BSU team has an experience of participation in the “International Cooperation” dimension of the “Capacities” Programme and “International Research Staff Exchange Scheme” of the “People” Programme none of which is the core activity of the Framework Programmes. Therefore, better understanding of the FP7 and deeper knowledge of its variable instruments is important for the team in order to ensure sustainable financial support for its research activities.

The INP BSU scientific output is evident through high quality publications which give it a status of internationally recognized experts in the area carbon nanotube based research, especially for THz applications of carbon based nanostructures. The international recognition makes it easier to promote this area of the research on the national level. Currently, such national R&D programs as “Convergence”, “Electronics and Photonics”, “Functional and Construction Materials, Nanomaterials”, “Nuclear Energy, Nuclear and Radiation Technologies”, as well as several grants by the Republican Foundation for Fundamental Research and Ministry of Education of Belarus, including those for young researchers provide the financial support for the INP BSU research activities on the topics mentioned above. The support on the national level makes it possible to expand the number of international cooperation instruments used by the focus team and asks for regular feeding it up with information about the wider range of INCO schemes, both on national and international level.

On the way to the project goal, a set of coupled tasks were solved. The project main S&T results/foregrounds can be stated and ranked as they contribute into the project goal and solution of related tasks.

I. To prove necessity and promising capability of nanoelectromagnetics in the core objective of FP7 Theme 4 ‘Nanosciences,Nanotechnologies, Materials and new Production Technologies – NMP’ and to develop a concept of nanoelectromagnetics as a perspective direction in NMP.

This goal was solved in Tasks 1.1 and 1.2 of Work program. Deliverables

The emergence of nano-sized structures as key building block of nanoelectronic and nanophotonic devices as well as fabrication of new materials with nano-scale structuring has extended to the nanoscale such classical problems of the circuit theory as operational properties and electromagnetic compatibility (EMC) of circuit elements, noise control, electromagnetic materials and so on. However, such an extension implies radical modification of the basic principles of circuit theory, which conventionally relies on macroscopic electrodynamics. Undoubtedly, electromagnetic simulation of nanostructures is one of the main research directions for modern electrodynamics. As a result,

A new research discipline – nanoelectromagnetics – has emerged as a synthesis of classical microwave electrodynamics and present-day concepts of the condensed matter physics.

Introduced for the first time (to our knowledge) in 2004 by key project leaders (S. Maksimenko and G. Sepyan, S.A. Maksimenko and G.Ya. Slepyan, Nanoelectromagnetics of low-dimensional structures, in "The Handbook of Nanotechnology: Nanometer Structure Theory, Modeling, and Simulation," Ed. by: A. Lakhtakia, SPIE Press, 2004, pp. 145-206), the nanoelectromagnetics concept attracts great interest among researchers and, as multi-disciplinary research topics, leads to many cross-disciplinary links. On one hand, nanoelectromagnetics is among the topics of classical electromagnetic societies, such as the International Union of Radio Science, or Antenna and Propagation Society (both very recently), on other hand, chemists and researchers working in condensed matter physics consider nanoelectromagnetics as promising filed for
applications. The BY-NANOERA consortium was among leading teams promoting NEM namely as multi-disciplinary field requiring joint efforts from different research communities, joint formulation of key concepts and problems, and joint work on the development of common language. Moreover, the Consortium was built to join complementary experience of partners in nanoelectromagnetics. Such a construction of the Consortium proved to be very fortunate in the Nanoelectromagnetics promotion and in developing a Prognosis of NEM.

The expert group has been created for the Prognosis elaboration and practical implementation. The expert group comprises representatives of the partner organizations INP BSU, TUB and INFN, as well as external experts: P. D'yachkov (IGIC RAS, Moscow, Russia), O. Kibis (NSTU, Novosibirsk, Russia), P. Lambin (University of Namur, Belgium), A. Lakhtakia (Pennsylvania State University, USA) G. Miano (Università Degli Studi Di Napoli Federico II, Italy).

An analytical review preceding the Prognosis discusses the following issues:

- Electromagnetic effects in nanostructures: simulation and experiment,
- Carbon nanotubes, graphene and other forms of nanocarbon in electromagnetics,
- Nano-resonators, -antennas, -transmission lines,
- Optical nonlinearity at the nanoscale,
- Nanostructured composite materials and thin films: synthesis and physico-chemical properties,
- Nanostructured composite materials for electromagnetic protection and protection against ionizing radiation,
- Ordered nanostructures and metamaterials to control electromagnetic fields,
- Biomedical applications of metal nanoparticles and nanocarbon,

The review states that some of above topics are fast converted into industrial technological solutions, such as nanostructured composite materials for electromagnetic protection, while others require on current stage significant financial and intellectual investments (metamaterials with nano-scale structuring for terahertz and optical ranges, biomedical and electronic nanostructured systems, quantum light and single-photon devices). Moreover, the review leads to the prognosis that the problem of electromagnetic compatibility (EMC) on nanoscale is expected to become a complicated and acute problem in the nearest future. Although today it is too early to speak about the development and production of multicomponent and multifunctional nanoelectronic systems (currently we mainly deal with the formation of the component basis of nanoelectronics), such systems will appear very soon raising the nanoEMC problem to the full extend. We can conclude that the EMC basic principles, as applied to nanoelectronics, must be drastically modified with respect to their macroscopic counterparts. The main reasoning for that is that classical EMC is completely based on the macroscopic electrodynamics, while the operation of nanoscale electronic devices is strongly influenced by the quantum-mechanical effects due to the spatial confinement of the charge carrier motion.

The growing role of nanoEMC in the nearest future and growing impact of energy-based intercellular nano-therapy are the key conclusions of the Prognosis. The nanoEMC concept will be presented for the first time to wide specialized community as a talk "Electromagnetic Compatibility Concepts at Nanoscale" by G. Slepyan et al., at the 2014 International Symposium on Electromagnetic Compatibility" (EMC'14/Tokyo) which will be held in Tokyo, from May 13 to 16, 2014. This talk is a result of a big collaborative work of BY-NANOERA consortium members and newly formed collaborations with EU and Belarus teams.

The Prognosis of the NEM development has been presented at FANEM'12 (International Conference “Fundamental and applied nanoelectromagnetics”, BSU, Minsk, Belarus, May 22-25, 2012); a Russian-language draft of the Prognosis has been published by the Belarus State University Publishers and is widely disseminated in Russian-language nano-community in both Belarus and Russia. English version of the Prognosis has been presented (and is planned for further dissemination) in a set of international meetings organized by the consortium and is on-line available at the Project website (D1.3 from WT2: List of Deliverables).
As Prognosis impact on the national level, we consider INP BSU entering the State R&D Program “Convergence” under the Project 3.4.01.1 “Development and implementation, on the base of the new research discipline “Applied nanoelectromagnetics”, of the national interdisciplinary platform on modeling, study and application of electromagnetic properties and processes in nanostructured objects and systems”. A set of lectures under umbrella title “Challenges and Perspectives in Nanoscale Electromagnetics” has been given by project coordinator at seminars in different institutions. Some examples are given below:

- Electromagnetic response of carbon nanotube-based composite materials, DAEIMI, Università degli Studi di Cassino, Cassino, Italy, September 23, 2010
- Potentiality of carbon nanotubes as a thermal agent for the destruction of malignant cells in RF exposing field, BioNanotechnology Research Center, Korean Research Institute of Bioscience and Biothechnology, Daejeon, Korea, February 14, 2011
- Potentiality of carbon nanotubes as a thermal agent for the destruction of malignant cells in RF exposing field, University of Latvia, Institute of Solid State Physics, Riga, Latvia, March 17, 2011
- Electromagnetics of nanostructures, BSU, Physical department, Acad. Sevchenko Award lecture, November 4, 2011
- Electrodynamics of carbon nanotubes: principles, models and open questions, Harbin institute of Technology, China, December 6-7, 2011 (2 lectures)
- Challenges and Perspectives in Nanoscale Electromagnetics, Defence Institute of Advanced Technology, Pune, India, November 16, 2012
- Electrodynamics of carbon nanotubes: principles, applications and open questions, University of Salerno, Dept. of Electronic and Computer Engineering, March 21, 2013
- Challenges and Perspectives in Nanoscale Electromagnetics, Weizmann institute of Science, Israel, November 28, 2013
- Challenges and Perspectives in Nanoscale Electromagnetics, Tel Aviv University, Israel, November 29, 2013

Prognosis has also been used (and presented) in a set of invited talks at international conferences.

II. To develop the strategy of INP BSU as a focus institution for the applied nanoelectromagnetics evolution on the national and European levels;

The core INP BSU team working in the area of NEM is made by the permanent staff of the Laboratory of electrodynamics of nonhomogeneous media, which is a part of the Research Institute for Nuclear Problems of the Belarusian State University, Minsk, Belarus. BSU is a national leader of the higher education in Belarus. It is a complex research and educational establishment with a clear innovative strategic focus. The organizational structure of the university includes 19 faculties, 3 research institutes, 4 national R&D centers, 114 research laboratories and 6 innovative industrial enterprises. Almost 880 professional researchers form the R&D staff. The Research Institute for Nuclear Problems, INP BSU, is one of the 3 BSU research institutes. The major areas of its research activities are nuclear physics and physics of elementary particles, nuclear optics of polarized mediums, physical basis of free electron lasers, methods and equipment for radiation and ecological disasters prevention, environmental monitoring systems, radiation protection in medicine and industry.

Since the mid-nineties, new topics - physics and electromagnetics of nanostructures as well as applied electrodynamics of microwaves - are actively developed in the INP’s Laboratory of electrodynamics of nonhomogeneous media. The current activities of the Lab are focused on fundamental and applied nanoelectromagnetics that is defined by the national thematic priorities of S&T activities for 2011-2015 and national research priorities formulated in the List of priority areas of basic and applied research. Nano-technologies and nano-materials are connected there to energy efficient technologies and radio-electronic technologies and systems.

Today, the staff of the Lab that is the INP BSU core team completely dealing with NEM comprises 20 employees, including 15
researchers and 5 technicians. 25% of employees are women. Half of the staff is under 35. In 2012, 50% of researchers and technicians spent at least 1 month doing research abroad.

In our understanding, this nucleus has got prerequisites for further successful developing in terms of competencies and size and reaching its vision.

A working group has been created for elaborating the INP Strategy in the field of nanoelectromagnetics. The group was formed by Belarusian scientists from BSU, National Academy of Sciences of Belarus and comprises an advisory board of EU team leaders of BY-NANOERA. A concept of the Strategy has been presented and discussed at the Policy Stakeholder Conference on “EU-Eeca Cooperation in Research and Innovation: The way towards 2020” (Warsaw, Poland 15-16/11/2011, www.policystakeholders2011.pl).

S.A. Maksimenko, “The role of the EU research and innovation programs in the surviving strategy of small and mid-size research team”.

A strong feedback to the INP Strategy has been given by the Benchmarking of the European, Eastern European and Central Asian RTDI Institutions from the field of Nano-Science/Nano-Technology, carried out in the frame of the project IncoNet EECA (http://www.inco-eeca.net) and, in particular, by European experts (Prof. Erich Gornik and Dr. Elke Dall, Austria, Dr. Paul Tomlins, UK) visiting INP BSU in April 2012.

The Strategy is a framework that underpins the INP BSU activities in the said research area for the upcoming decade and reinforcing its capacities through the institutional development of this still-young research discipline. It formulates mission statement, describes the INP BSU strategic vision and goals till 2025 and proposes an action plan by which these goals will be achieved. The document includes the research program component areas and identifies specific objectives toward meeting the INP BSU vision. Despite the fact that developing a Strategy is a must for the INP BSU, it’s also a need and a will of the team to summarize the existing body of knowledge, monitor the overall tendencies of the nanoscience development, explore the changing funding instruments at the turn of budget cycles on the national (2011-2015/2016-2020) and EU level (2007-2013/2014-2020) and adjust its goals and plans to the changing circumstances.

On the national level, Strategy orients INP BSU on active work within national R&D programs aiming at setting up and developing of nanoindustry in Belarus till 2020. Appropriate action plan has been adopted in February 2013. As a first step, the Nanoindustry association has been established in Belarus and, in accordance with the Concept, INP BSU enter the association, while the BY-NANOERA coordinator Prof. Sergey Maksimenko, recently appointed for the INP BSU Director position, enter the Interdepartmental Coordination Board on the Nanoindustry Development in Belarus, which is considered as a tool to influence the strategic development of nanotechnologies in Belarus and, in particular, to take part in priorities setting, budget distribution and developing mechanisms of the state support for the nanoindustry. Having rich experience in participation in EU INCO programs and similar international actions, INP BSU consider as its mission to convince national nanocommunity and science administration in necessity and profitability of close synchronization of national programs with corresponding policy of EU. While the share of budget funding for research in the total funding of R&D is decreasing and the total funding of R&D didnot surpass 1% GDP for years, the Government considers the nanoindustry to be one of the most prospective branches to invest in and plans to spend 30 mln USD annually to support it in 2013-2015. NEM and connected areas of research is completely in line with the thematic priorities defined by this Plan. Taking into account high capital intensity of R&D and commercialization in this area, the focus is made on integration of all actors within the chain (researchers, developers, venture investors, entrepreneurs, consumers, etc.) and setting up of cluster-type structures (technological platforms, national technological networks, associations, etc).

The Concept proposes INP BSU as a nucleation point for research in physics of nano-sized objects and nanostructured systems and materials conducted in BSU at different departments. In that case, INP BSU and the Institute of Physical Chemical
Problems, BSU, can form correspondingly equipped national-scale center of nano research, one of four centers overseen by the actions plan mentioned above. Also, it is planned to set up a specialized incubator of small business enterprises which will provide essential number of jobs for nano-oriented SMEs. It’s supposed to be hosted by the S&amp;T Park “Polytechnic”, the INP BSU partner organization. The Concept also raises such vital for the INP BSU challenges as education and technology transfer in nanoarea and strongly orients INP BSU staff on courses development and teaching at BSU physical department, as well as attraction of MS and PhD students.

The Strategy is based on detail SWOT analysis and its recommendations and formulates very ambitious goal: By 2025, the INP BSU will become a center of excellence in Nanoelectromagnetics benefiting from its leading position in Belarus nanoscience and nanotechnology community and complete integration in the European Research Area. In alliance with the Belarusian State University, it will be an important center of nanoscience education and innovations in Belarus and Eastern Europe.

The INP BSU realizes its mission in

1) Carrying out the highest quality research in NEM and connected areas to support the Belarus nanotechnological research endeavor and further increase partnerships with world-class research centers and industrial companies in the country and outside it to apply the research results in such social challenges as

- Higher and post-graduate education,
- Secure, clean and efficient energy,
- Health, demographic change and wellbeing;

2) Maintaining the Institute’s scientific vigor by continuous renewal and updating of its research interests and skills and providing wide opportunities to its staff for career development along their professional life,

3) Training and developing high quality young researchers.

The Strategy states several long-term goals:

1. To provide R&amp;D support for breakthrough projects in NEM, as well as bridging the gap between research and innovation within the main priorities: electromagnetic compatibility on nano scale (nanoEMC), nanocarbon based CNT devices and materials, radiation protective materials and technologies, solar energy, nanoscience and nanotechnology education.

2. To ensure sufficient and stable financing for the INP BSU research and innovation activities on the base of multi-vector research policy which primarily should be oriented on national science and innovation market but also should be worth to attract international funds, both European and Asian (China, India, South Korea, etc).

3. To sustain a highly qualified and motivated core team working in close contact with the host University. The internal institute policy should ensure each member of the INP BSU team benefits from participation in international projects in terms of international mobility, acquiring new skills and best practices, exchanging results, publicizing and disseminating, and, jointly with the host university, should be oriented to get into specialized international projects on professional training of young researchers in nanosciences.

4. To improve the INP BSU research infrastructure comprising effective exploitation of equipment available at the university centers of collective use, formation of own research equipment park, and extension of inter-institutional cooperation, both on national and international levels.

III. To establish network with research centers in Member States or Associated Countries in the field of applied
nanoelectromagnetics aimed with the progress in solving concrete scientific problems and submission of joint research projects.

Within the BY-NANOERA project, serious efforts have been undertaken both for the cooperation reinforcement within the Consortium and for the establishing of new collaborative links. The BY-NANOERA research consortium

Institut fuer Festkoerperphysik, Technische Universitat Berlin (TU Berlin)
Instituto Nazionale Di Fisica Nucleare INFN (Italy)
Foundation For Research And Technology Hellas (Greece)
Institute of mechanics BAS (Bulgaria)

Has been significantly extended by new members, actively involved in the research activity in nanoelectromagnetics:

Centre of Strong Fields Physics, Yerevan State University, Yerevan, Armenia
Physics Department, FUNDP—University of Namur, Namur, Belgium
Universite de Brest, Lab-STICC, Brest, France
University of Lorraine, France
University of Eastern Finland, Joensuu, Finland
University of Salerno Fisciano (SA), Salerno, Italy
University of Naples Federico II, Naples, Italy
University of Cassino, Cassino, Italy
Institute of Polymer Materials, Riga Technical University, Riga, Latvia
Center for Physical Sciences and Technology, Vilnius, Lithuania
Vilnius University, Vilnius, Lithuania
Boreskov Institute of Catalysis SB RAS, Novosibirsk, Russia
Nikolaev Institute of Inorganic Chemistry, SB RAS, Novosibirsk, Russia

Old successful collaboration with the Institute for solid state physics, TU Berlin, has been continued under the BY-NANOERA support resulting in a set of publications in high-ranked journal -Physical Review B. The last paper from this series, H. K. Avetissian, G. F. Mkrtchian, K. G. Batrakov, S. A. Maksimenko, And A. Hoffmann, Nonlinear Theory Of Graphene Interaction With Strong Laser Radiation Beyond The Dirac Cone Approximation: Coherent Control Of Quantum States In Nanooptics, Phys. Rev. B 88, 245411 (December 10, 2013), contribute into nanoEMC problem for quantum light and, we hope, starts a promising series of works in this field. This publication also presents new triangular cooperation scheme TU Berlin - INP BSU - Yerevan State University (Armenia). Appeared under effect of BY-NANOERA, the cooperation is mainly supported by bilateral projects.

Very effective collaborative link has been established and developed with the INFN team. More than 15 joint papers have been published in the last three years on nanocarbon based composite materials for electromagnetic application.

As a central scientific result of the research activity in NEM during the BY-NANOERA project, obtained in cooperation with TUB and Center for Physical Sciences and Technology, Lithuania, is an experimental proof of localized plasmon resonance in thin films containing either single-walled carbon nanotubes or nanotube bundles of different length (Physical Review B, 85, 165435 (2012) . Fourier-transform infrared spectroscopy showed that an optical-density peak, the same as a terahertz conductivity peak, shifts to higher frequencies as the nanotube lengths are reduced—in agreement with a similar tendency predicted for the localized plasmon resonance in finite-length SWNTs in early theoretical publications of INP BSU. This result is the first direct demonstration of antenna properties of CNTs and opens a way for the design of terahertz-range functional materials with tunable properties.

INP BSU participated in a large number of research conferences and workshops presenting collaborative research activities
within implementation of the scientific problems enumerated in Task 2.1 of the WP2. Some of them are listed below:

- 219th ECS Meeting, Symposium H4 - Carbon Nanotubes and Nanostructures: Applications and Devices, Montreal, Canada (May 1-6, 2011), [http://www.electrochem.org](http://www.electrochem.org)
- European Polymer Congress EPF 2013, June 16–21, 2013, Pisa (Italy)http://www.epf2013.org/
In particular, 13 invited talks have been delivered since the project start (As examples, two talks are given in supplementary materials, Kuzhir-Solerno 2013-21-03.pdf and Maksimenko Weizman 2013.pdf):


A.V. Kukhta "Optical and electrophysical properties and applications of organic and organic-inorganic materials and thin film nanostructures", 1st Int. Conf. on Functional Materials for Defence, 18-20 May 2012, Pune, India. (Invited talk)


S. Maksimenko, Electrodynamics of Carbon Nanotubes: Basic Approaches, Potential Applications and Open Questions, (Pleunary

The activity on promoting INP BSU’s research capacity and potential for international collaboration was (and is) implemented from the very beginning of the project not only during presentations of research results at different conferences listed above, but also in special actions, like the following:

- A special talk "Presentation of new EU projects FP7-247007 CACOMEL and FP7-266529 BY-NanoERA" has been delivered by S. Maksimenko at The 2nd International Workshop on Nanocarbon Photonics and Optoelectronics, Koli/North Karelia/Finland, 1-6 August 2010
- The Nanoelectromagnetics portal http://www.nano.bsu.by/ has been created which includes the BY-NanoERA Website. (D1.1 from WT2: List of Deliverables)
- A foreword article anticipatory a special section of the Journal of Nanophotonics (SPIE) “Fundamental and Applied Nanoelectromagnetics” published in the second half of 2012
- A special issue "Electromagnetic processes in nanostructures" of national Russian-language magazine "Science and Innovation", where the promoting paper "Nanoelectromagnetics - a prospective direction of scientific research" has been published together with a set of thematically close invited papers of scientists from Belarus, Russia and United States.
- Three conceptual /review articles promoting nanoelectromagnetics and BY-NANOERA and oriented on more specialized university audience have been published (or accepted for publications), one in Belarusian magazine "Vestnik of the Belarusian Foundation for Fundamental Research", one in magazine "Vestnik of the Kursk University" and one in the Journal of Bulgarian Academy of Science (in Bulgarian)
- FP7 infoday has been organized in Minsk, Belarus, October 19, 2011
- An article “Institutional development of nanoelectromagnetics: The place of Belarus in the expanding European scientific space" has been published in Eurobulletin, September 2012.

A set of promoting materials has been prepared and published. (D1.2 from WT2: List of Deliverables). Promoting materials and special promoting talks were delivered at all scientific events organized by the consortium.

Essential factor influencing attractiveness of the nanoelectromagnetics research among Belarus teams and status of the project target institute as a leader of this research direction, is that four INP BSU participants of BY-NANOERA, K. Batrakov, P. Kuzhir, G. Slepyan and S. Maksimenko, have been awarded (October 2011) by the highest BSU award for achievements in natural sciences - the Belarusian State University Award named by Academician A.N. Sevchenko for the work "Electromagnetics of nanostructures". This Award serves as a successful story for Belarusian teams seeking the development strategy.

As an important result of the activity within BY-NANOERA we consider significant growth during last three years of h-factors of the project key persons (S. Maksimenko and G. Slepyan: from 16 to 22, P. Kuzhir: from 14 to 25) and formation of deserved h-factors of young scientists from INP BSU team.

Three PhD thesis directly related to NEM and supported through BY-NANOERS program of visits have been prepared for defense:

Yugen Yerchak, Propagation of Rabi-waves in low-dimensional semiconductor nanostructures, defense has been appointed on
February 2014
Dmitri Bychanok, Effects of interaction of high-frequency field with different nanocarbon composites, defense is expected in April 2014
Alesia Paddubskaya, Finite-size effects in electromagnetic response of nanocarbon-based composite materials (tentative title), defense is expected in June 2014
Three other PhD theses are expected in 2015.

Since there is a two-level system of scientific degrees in Belarus - PhD and Doctor of Science (Research professor, Doctor Habilitate) - second defense is a very important step in scientific career. In addition to two existing Doctors of Science in the INP BSU team, we expect DSc theses defenses by Dr Polina Kuzhir (2014), Dr Konstantin Batrakov (2014) and Dr. Mikhail Shuba (2015).

The fast growth of number of PhD defenses and appearance of several new Doctors of Science in the team makes evident a significant institutional progress in the INP BSU team.

One of the most important result of the BY-NANOERA project is the establishing of new collaborative links and submission of joint INCO projects. The spectrum of bi-lateral instruments used by the INP BSU team is composed of BMBF grants to support mobility of German and Belarusian researchers within the bi-lateral research projects in priority areas, World Federation of Scientists grants for young researchers, grants for young EECA researchers for short-time work in Russian research organizations provided by the Russian Foundation for Basic Research, grants to support bi-lateral research projects with Ukraine, Moldova, Lithuania, Latvia and several other countries provided by the State Committee on Science and Technology and Belarusian Republican Foundation for Fundamental Research. Among them, the following project were obtained and have been (are) carried out:

A development of new prospective materials for the ionizing radiation protection on the base of phosphate compositions modified by mico- and nano-sized boron nitride whickers, Francevich Institute of material science problems, NANU, Kiev, Ukraine/INP BSU, Minsk, 2011-2013

Polymer composite materials modified by nanocarbons for electromagnetic applications, Institute for Polymer materials, Riga Technical University, Riga, Latvia, INP BSU, Minsk, 2012-2013.

Speaking about young scientist mobility support, in addition to training visits carried out within the BY_NANOERA project, the following actions should also be mentioned:

Four grants for young scientists visiting leading Russian research institutions have been obtained. D. Bychanok visited Nikolaev Institute of Inorganic Chemistry in 2011 and in 2012, and N. Volyinets visited this institute in 2013, while V. Saroka visited Institute for Biochemical Physics RAS, Moscow, Russia in 2013.

Three INP BSU young scientists (D. Bychanok, A. Paddubskaya, A. Pliushch) have been granted by stipendiums from the World Federation of Scientists, National Scholarship Programme in the frame of the topic “Science and Technologies for Developing Countries”

The FP7 is definitely the most known program among those funded by the European Commission, both within the INP BSU team and Belarusian research community as a whole. The following FP7 projects have been obtained due to BY-NANOERA activity:

Fundamental and Applied Electromagnetics of Nano-Carbons, EU FP7 project FP7- 318617 FAEMCAR, Call ID FP7-PEOPLE-2012-IRSES, 2012-2016, Principal Researcher: Ph. Lambin (University of Namur, Belgium), team leaders: Y. Banis (Vilniaus
Universitas, Lithuania), S. Bellucci (Istituto Nazionale di Fisica Nucleare, Frascati, Italia), L. P. Biró (Research Centre for Natural Sciences, Hungarian Academy of Sciences, Budapest, Hungary), L.A. Chernozatskii (Institute for Biochemical Physics RAS, Moscow, Russia), G. I. Dovbeshko (Institute of Physics, NASU, Kiev, Ukraine), P. Kuzhir (INP BSU).

Carbon-nanotube-based terahertz-to-optics rectenna, EU FP7 project FP7-612285 CANTOR, Call ID FP7-PEOPLE-2013-IRSES, 2013-2017, Principal Researcher: M. Portnoi (University of Exeter, UK), team leaders S. Maksimenko (INP BSU), G. Slepyan (Tel Aviv University, Israel)


IV. To organize a set of workshops and seminars on nanoelectromagnetics

During the three years of the project, the following events have been organized under the direct support from BY-NANOERA:

A special session "Nanoelectromagnetics" at the International conference on Physics, Chemistry and Applications of Nano-structures “Nanomeeting 2011”, May 24-29, 2011, http://www.nanomeeting.org/ has been organized. The BY-NANOERA support is acknowledged in the Conference Program and Proceedings (World Scientific, 2011) Prof. S.A. Maksimenko was an Organizing Committee Member of the conference. About 15 NEM-related talks including one invited lecture (Prof. P. Lambin, Belgium) have been delivered during the conference. This session initiated several new collaborative links

A Special Session “Electro-dynamics of nanowires and nanotubes” headed by Dr G. Slepyan has been organized with the emphasis on Nanoelectromagnetics at the International Conference on Electromagnetics in Advanced Applications & IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications, September 12-17, 2011 Torino, Italy, http://www.iceaa.net/. Also, two other sessions were co-chaired by Prof. G. Slepyan.

A Special Nanoelectromagnetics session chaired by S. Maksimenko has been organized at the International workshop Nanoscience and Nanotechnology N&N11, INFN, Frascati, Italy, September 19 – 23, 2011. The INFN team leader S. Bellucci was a conference chairman while S. Maksimenko and P. Kuzhir entered the Conference organizing committee. A Special meeting on BY-NanoERA has been held on September, 20 as well and the prognosis group meeting was also organized. This event started a series of nanoelectromagnetics sessions which has been held within the next two workshops:

International workshop Nanoscience and Nanotechnology N&N12, INFN, Frascati, Italy, October 1-4, 2012
International workshop Nanoscience and Nanotechnology N&N13, INFN, Frascati, Italy, October 1-4, 2013

BY-NanoERA Bilateral Seminar has been held in Bulgaria 17-24 August 2012, Sofia. Four members of INP BSU team, two experienced scientists and two early stage researches, visited Institute of Mechanics BAS and had very interesting and helpful discussions. The seminar started fruitful collaboration of two teams. Several young researches visited later Institute of Mechanics for doing joint research, and S. Maksimenko has been invited to write a review-type paper for /Journal of Bulgarian Academy of Science.

A special session “Nanoelectromagnetics“ at the International conference on Physics, Chemistry and Applications of Nano-structures “Nanomeeting 2013”, May 28-31, 2013, http://www.nanomeeting.org/. Prof. S.A. Maksimenko was an Organizing Committee Member of the conference. About 15 NEM-related talks including one invited lecture (Prof. A. Maffucci, Italy) have been delivered during the conference. This session initiated several new collaborative links.

A Special Session “Electromagnetic properties of carbon nanostructures“ has been organized and chaired by G. Slepyan
A special session MS03 “FP7-BYNanoERA: Institutional Development of Applied Nanoelectromagnetics” has been organized by Prof. Rumiana Kotsilkova at 2-th National Congress on Theoretical and Applied Mechanics, St. St. Constantine and Helena, September 23, 2013 – September 26, 2013

A central event of the whole project was the International conference “Fundamental and Applied NanoElectroMagnetics” FANEM’12, which was held on May 22-25, 2012, at the Belarusian State University, Minsk, Belarus, http://www.nano.bsu.by. Some details of FANEM’12, several conference photo and copy of Internet publications are presented in supplemented materials, FANEM presentation.pdf. The file Polygraphy FANEM’12.pdf presents printing art of the conference.

The conference aimed to provide a forum for scientists specializing in different areas of the nanoparticles and nanostructured materials synthesis and applications to interact with their counterparts working in the areas of electromagnetic theory and applied electromagnetics. Fruitful discussions were held both stimulating the development of nanoelectromagnetics and introducing the language and the problems of the present-day electromagnetics and photonics to the nano-materials research community. The conference thus had a very wide scope that encompasses various aspects of general theory, modeling, design, synthesis, characterization, applications ranging from commercial thin-film coatings to metamaterials to circuit components and nanodevices:

- Electromagnetic effects in nanostructures: simulation and experiment,
- Carbon nanotubes, graphene and other nanocarbon forms in electromagnetics,
- Nano-cavities, -antennas, and -transmission lines
- Optical nonlinearity on nano-scale
- Nano-structured composite materials and thin films: synthesis and physical chemical properties
- Nano-structured composite materials for electromagnetic shielding and ionization radiation protection
- Ordered nanostructures and metamaterials for electromagnetic fields manipulation and processing
- Biomedical applications of metallic nanoparticles and nanocarbons
- Quantum light processing and single-photon devices

The conference was co-chaired by project coordinator Prof. Maksimenko and BSU vice-president Acad. O. Ivashkevich. Metolit and INP BSU formed the working group on the conference organization. International Program Committee comprises representatives of BY-NANOERA consortium, leaders of several other FP7 project teams (FP7-230778 TERACAN, FP7-247007 CACOMEL, FP7- 318617 FAEMCAR), representatives of the Intrnational Science and Technology Center (ISTC) project B-1708, and several recognized scientists from different countries. The conference was also financially supported by BSU, by ISTC through a special conference grant, and by Representative office of Optec Holding B.V. in Belarus. About 120 scientists from 19 countries (including e.g. USA and India) attended the conference.

A special tutorial “Emerging Nanoscientific Developments” has been presented by 6 key lectures and 11 invited talks. Corresponding certificates were given to MS & PhD students. The list of key lectures is as follows:

Prof. Akhlesh Lakhtakia, Pennsylvania State University, USA, Surface Multiplasmons
Prof. Philippe Lambin, University of Namur, Belgium, Elasticity at the nanoscopic scale
Prof. Sergey Gaponenko, Stepanov Institute of Physics, Belarus, Enhanced light-matter interaction in plasmonic nanostructures
Prof. Axel Hoffmann, Institut für Festkörperphysik, TU Berlin, Germany, Towards Single Photon Sources at Room Temperatures for Quantum Cryptography Application
Prof. Gintaras Valusis, Center for Physical Sciences and Technology, Lithuania, Solid-state based room temperature terahertz
Prof. Gregory Slepyan, Research Institute for Nuclear Problems, Belarus, Concept of photonic density of states in nanoelectromagnetics: theory and applications

A special section "Fundamental and Applied Nanoelectromagnetics" has been organized in Journal of Nanophotonics, (http://spie.org/x3650.xml) with S. Maksimenko as Guest Editor where selected papers from FANEM’12 have been published.

ByNanoERA CLOSING Seminar has been held on 28 October 2013, at the Institute for Nuclear Problems, INP, Minsk. closing remarks to the project are given as supplementary material in the file 13’BY NANOERA October closing meeting.pdf. Representatives of INP BSU, HELAS, INFN, BELISA, iMech-BAS, METOLIT took part in the seminar. Participants stated successful finalizing of the project and discussed joint actions in the future. In addition to the seminar, Two invited talks have been delivered at the BSU Physical Department:

S. Bellucci, "Carbon nanotubes-induced biological effects", October 29, 2013

Along with students, teachers and researchers of BSU, researchers from different institutes of NAS Belarus and representatives of medical research community participated.

The seminar was organized in such a way to provide possibility for BY-NanoERA consortium numbers to meet new partners and to discuss the future joint activity. The following researchers visited Minsk in that period and took part in discussions:

Prof. P. Lambin (University of Namur, Belgium)
Prof. Yu. N. Shunin and Dr. Lobanova (University of Latvia, Institute of Solid State Physics, Riga, Latvia)
Prof. P. Dyachkov (Kurnakov Institute of General and Inorganic Chemistry, RAS, Moscow, Russia)
Dr. H. Mark (Research Centre for Natural Sciences, Hungarian AS, Budapest, Hungary)
Prof. L.A. Chernozatonskii (Institute for Biochemical Physics RAS, Moscow, Russia)
Prof. G. I. Dovbeshko (Institute of Physics, NASU, Kiev, Ukraine)
Dr. J. Macutkevic, (Vilniaus Universitetas, Lithuania)

The project coordinator Prof. S. Maksimenko was a member of Organizing or Program Committees of the following scientific events directly related to the activity field of INP BSU team:


2nd Global Conference on Materials Science and Engineering (CMSE 2013), Hubei University of Science and Technology,
As a result of recognizability of INP BSU team achieved on international level owing, in particular, the activity within BY-NANOERA project, key members of the INP BSU team (S. Maksimenko, G. Slepyan, P. Kuzhir, M. Shuba) are often invited as referees for many high-ranked journals, such Physical Review Letters, Physical Review A and B, Applied Physics Letters, Journal of Applied Physics, NanoTechnolology, IEEE Transactions on Nanotechnology, IEEE Transactions on Antennas and Propagation, etc. S. Maksimenko is also a Referee for the Evaluation of research projects on behalf of the Italian Ministry of Education, University and Research and the Evaluation of research products (VQR 2004-2010) on behalf of ANVUR, and an expert of the foundation "Skolkovo" (Russia).

V. To develop training modules to build competency and facilitate the participation in FP7 of INP BSU

The objective of a cycle of training undertaken by the BY-NanoERA consortium members BelISA and Metolit in close cooperation with the INP BSU was to increase the knowledge of the INP BSU staff and representatives of other research institutions on the FP7 and other INCO Community and national programs, and also to improve its skills in presenting competencies and project ideas, partner search and proposal development. In addition to excellent research, these skills should help the focus team to expand its international cooperation and integrate in the European Research Area.

According to the Annex 1 and basing on the assessment of the INP BSU training needs, 3 training modules have been developed by BelISA. While developing the program of trainings, the interests and needs of the young scientists, PhD students and medium-experienced researchers of the focus team have been given a priority in order to increase the number of the INP BSU staff with sufficient skills in FP7 matters and improve their capabilities in proposal developing and drafting.

The trainings were conducted in May 2011, October 2011 and September 2012 in Minsk. In total, 71 participants attended the trainings. Over 35% of them represented the INP BSU and BSU, while almost 65% were invited from outside. They represented the research centers of the National Academy of Sciences of Belarus and universities. The number of trainees from companies was symbolic. 44% of participants were women. The trainings have been implemented by BelISA. For some specific tasks, external experts, both national and international were invited. Technical organization has been provided by the Metolit team from the Belarus National Technical University. Presentations and photos of the trainings are available at

- http://fp7-nip.org.by/ru/6rp/news/BYNANOERA_2.html and

56% on the total number of participants filled in the feedback forms. Analysis of the feedback shows that expectations of 97% attendees have been met.
The strong leadership and the international collaboration are key drivers to keep a good spirit in the group. The international collaboration is the main benefit for the PhD students and young researchers as it gives them a chance to spend some time abroad, acquire new knowledge and know-how thus developing their research carrier and human experience. What is important that the staff, in general, is competent in English, a key attribute for building an international reputation in the English speaking community, as well as for collaborations with EU partners. Despite of that, the nucleus of the team capable to actively take part in a consortium and proposal developing and drafting an application according to the EU requirements is limited to 2-3 persons. Therefore, improving the skills of the rest part of the team and especially of young and mid-aged researchers in presenting their competencies, partner search and developing their own partner networks, international communication, proposal development, and communicating the research results to scientific community and wider is of significant importance. Obviously, growing up a proposal developer is a long process however the BY-NanoERA training program is going to contribute to this process. BY-NanoERA - 266529.

Last but not least, for participation in the trainings researchers from other R&D institutions, universities and companies are going to be invited. Presenting the BY-NanoERA project at the trainings to them is an additional opportunity to communicate the benefits of participation in the FP7 to Belarus research community, disseminate projects results and promote local networking.

In order to develop a program of trainings, a questionnaire has been developed and disseminated by BelISA among the INP BSU staff in order to better define the training needs. 18 persons have filled in the questionnaire. Of them, 17 noted they had heard about the FP7. Most of them were aware the FP7 was the large program for supporting the international collaboration funded by the European Union and Belarusian organizations were eligible and actually took part in it. Only 2 respondents said they knew the “must know” information and personally took part in proposal drafting and submission. The rest were just aware of basic rules and were sincere to tell their knowledge of the FP7 was fragmentary.

When asking about the concrete aspects of the Programme, it’s evident that at least half of the staff considers they understand well the philosophy and know general rules. 30% know the FP7 structure and specific programmes, while such aspects as financial and legal issues, IPR, evaluation procedures and project implementation seem to be familiar just to the most experienced group of 2-3 persons who took part in developing the BY-NanoERA and other FP7 proposals. It is the same group of top-researchers that declares it knows how to find a good coordinator, develop and submit a proposal, negotiate a contract, manage a project and report on FP7 project. Little bit more respondents are aware of partner search tools, rules for international communication and consortium development. So, we came to the conclusion that financial, legal, IPR, evaluation and other rules of the FP7, as well as precise explaining the project life cycle and a role of a “regular” partner in it will be the core content of the trainings.

Though the INP BSU team as a whole is very active in INCO, its younger part is not aware of the whole spectrum of programs and grant schemes it may exploit. That’s why one of the tasks of the training is to present in detail the already known instruments and open up the new appropriate programs and grant schemes which are not used by the INP BSU so far. It’s worth to note that all respondents are eager to improve their knowledge in FP7 and other INCO programs.

Taking into consideration the results of the questionnaire and a gap in FP7 knowledge between the leading staff and young and less experienced researchers which has become evident, it was decided

1) To adapt the program of trainings to the needs of young and less experienced members of the INP BSU team;
2) The INP BSU staff will form the nucleus of the trainees’ group and gradually improve understanding of the FP7 and INCO skills from training to training. To ensure the continuity, at the beginning of the next training a short overview of the previous one will be provided;
3) To open the trainings to researchers for the other R&D centres, universities and companies, including SMEs;
4) To organize trainings in the most practical way – exercises, working in groups and pairs, informal communication, etc., as
well as to include presentations by external speakers on the real cases of participating in FP7 projects and evaluating proposals;
5) To include a short presentation of the BY-NanoERA project in each training in order to update participants about the project implementation and deliverables.

A training program has been combined of 3 trainings.

The first training titled “How to get in? General introduction to FP7 and basic soft skills needed to express your interest” included introduction to the FP7 – rules for participation and structure of the Programme; understanding of a call and work programme (based on the content of the draft NMP Work Programme 2012; developing a strategy of getting in a consortium; partner search tools, etc. The other part was devoted to developing of a partner profile, .ppt presentation on a partner expertise and oral presentation of a partner’s competences (in the form of elevator speech). The training was planned as 2-day event. After presenting the tips, the trainees were asked to work at home and be ready to present on the second day a profile, or .ppt, or oral speech about their competences (competencies of their virtual team) or project idea. The results were evaluated by the trainees and discussed. The second day was finalized with an overview of the opportunities for INCO beyond FP7. The training 1 was held on 19-20 May 2011. It was conducted by Olga Meerovskaya, BellISA with participation of Dr Tatyana Lyadnova, BellISA (partner search tools). Presentations are available at http://fp7-nip.org.by/ru/nip/news/BYNANOERA_1.html.

The idea of the second training named “You are in a consortium: obligations and requirements for a partner in FP7 project” was to present step by step the way of a partner from getting in a consortium to a project start. The first part was devoted to presenting the information required from a partner at the proposal development and submission stages – developing a project idea, registering a proposal, drafting a proposal (parts A and B), calculation of a budget, submission and its follow-up. The second part was mostly about the evaluation of a proposal and legal issues (grant agreement, consortium agreement and IPR). Also, the national procedures for registering of a FP7 project and VAT exemption were explained in details. The agenda included 3 exercises on financial issues (calculating EC funding using the lump sum, calculating the personnel costs, calculating the payments). The training 2 was carried out on 18 October 2011. It was co-conducted by Olga Meerovskaya and Raphael Koumeri, Research and Innovation PLANET S.A. Greece. The last has experience of developing successful FP7 applications and project coordination. For evaluation issues Dr Anna Pobol, Economics Faculty, Belarusian State University was invited to present her personal experience of FP7 evaluator. Presentations and photos are available at http://fp7-nip.org.by/ru/6rp/news/BYNANOERA_2.html.

The third training was devoted to a proposal development. It was based on the requirements of the International Research Staff Exchange Scheme (IRSES) of the FP7 “People” Programme, 2013 call for proposals. IRSES is an example of a simplified application in terms of a proposal content and size. Therefore, it gives an opportunity for partners from the third countries to play an active or even a key role in proposal development and drafting. At the same time, IRSES application contains all elements typical for the “Cooperation” Programme proposals. Thus, the knowledge and skills received at the training could be further used for applying in the different dimensions of the FP7.

The training 3 “took place on 28 September 2012 back to back with the Workshop “Opportunities for research career development and international mobility”, 27 September 2012, http://fp7-nip.org.by/ru/6rp/news/it_sem27_09_2012.html. It was held by Olga Meerovskaya. The experience of proposal development and participation in the real IRSES project SISET was presented by Dr Valentyn Nazarov, Institute of Physical and Chemical Problems, Belarusian State University. Presentations and photos are available at http://fp7-nip.org.by/ru/6rp/news/Info_tr_28_09.html.

Dissemination of information about the trainings and invitation of trainees, invitation and organization of a visit of the external trainer and external speakers, as well as printing materials, catering and other logistics have been done by Metolit. In total, 71 participants attended the trainings. Over 35% of them represented the INP BSU and BSU, while almost 65% were invited from
outside. In order to ensure participation of the INP BSU staff the timing of the trainings was agreed with the BY-NanoERA Coordinator however it was not an easy task due to intensive international mobility of the INP BSU researchers. The non-INP BSU trainees represented the research centers of the National Academy of Sciences of Belarus and universities other than the BSU. The number of trainees from companies was symbolic. 44% of participants were women.

VI. To propose the reinforcement scheme developed for INP BSU as a model for the Belarus teams’ incorporation into European Research Area.

The basic elements of the BSU INP Strategy,

To show research progress recognizable by the scientific community on both national and international levels;
To enter into national R&D programmes;
To join education process attracting young generation;
To establish international collaborative links

These are very simple but not so easy for implementation. Even so, reported at many events in Belarus and abroad, listed above, supplemented by helpful information about EU FP7 and other INCO programs given during training courses, and supported by real success of INP BSU team in the development of international collaborative links and participation in a set of INCO project, reinforcement scheme turns out to be very attractive for implementation. BelISA leader Dr. Olga Meerovskaya and key members of the INP BSU team are very popular consultant for many labs and individuals from Belarus academic community. Perhaps, this is the best evidence of the successful realization of the BY-NANOERA project and achieving the main project goals.

Potential Impact:

I. Actual and potential impact of BY-NANOERA

To understand the contribution of the BY_NANOERA project into the RTD capacity building in Belarus, one should have a notion of structure and organization of the Belarus national RTD system. In Belarus, traditionally the program method is used for financing RTD. In 2007 over 60 national programs of different types focused on or partly included RTD were supported. The number of programs has been reduced to 45 to 2013. Some of them cover definite stages of RTD, which is basic research, applied research, and also developments and demonstration, but the most of them are complex programs which cover all stages pointed above. Providing concentration of financial and intellectual resources on concrete target problems, the program method turns out to be less susceptible to novel frontier topics, which permanently emerges as results of initiative small-budget investigations. International collaboration in its different forms plays an important role namely as a tool for supporting such researches. The INP BSU activity in the field of nano electromagnetics belongs to that type of research. Indeed, during the BY-NANOERA realization, the biggest effort in the scientific activity have been directed to

laying of scientific foundation of the nano electromagnetics as a novel interdisciplinary science trend comprising the traditional electrodynamics and the present-day physics of nanostructures;

direct exploitation of basic ideas of the nano electromagnetics for solving concrete applied problems, that is, laying the applied nano electromagnetics as a RTD tool

Generally, one can conclude that a significant progress has been achieved on the way to that very ambitious goal, and this progress is directly related to the qualitatively new step in the INP BSU team development - institutional development of nano electromagnetics, as it is formulated by the project title. A large number of invited talks delivered by the team members at different international conferences, publications in prestigious journals and prevalent growth of experimental works among
them, and fast increase of h-factors of both key INP BSU members and young scientists (see previous section for details) make the above statements evident. Thus, we see significant impact of the project in the development of a wide research direction covered by the core objective of FP7 Theme 4 ‘Nanosciences, Nanotechnologies, Materials and new Production Technologies – NMP.

The key message of the word “institutional” (that is, impact of namely this project) is to achieve incorporation of applied nanoelectromagnetics into the Belarus research area as a topic corresponding to priorities in national RTD strategy, and recognition of the INP BSU team as a leading team in this field on national level and as a respectable expert team on international level.

The NEM Prognosis and INP BSU Strategy as well as internal dissemination actions of other types (training courses, etc.) worked on reaching that at the outputs. As was mentioned, nanoelectromagnetics has been included as a topic into a State Program "Convergence". At present, Belarusian academic community is in expectation of a systematic reform of the RTD, announced in December 2013 at the General meeting of the NAN of Belarus. As one of announced actions, breakthrough directions of RTD are actively discussed and nanoelectromagnetics is among them, especially its new topic called nanoEMC.

Thus, the essential impact of the BY-NANOERA is a significant increase of the INP BSU competitiveness on the national RTD market. This allows us to pretend on the status of National Center of Excellence with corresponding growth of available funds, which we plan to direct first of all to the renovation and extension of the INP BSU experimental capacity. We clearly understand that this is a long way, especially taking into account problems of the Belarus national economics, but BY-NANOERA project built foundation for the further motion.

Very important technical impact of BY-NANOERA is an significant improvement and extension of experimental skills among INP BSU young scientists, which was possible due to a wide program of training visits implied by the project. Acquired experience allowed us to form our own program of experimental research of isolated nano-sized objects and nanostructures and provided access to deficit equipment. Experimental work with nanostructured materials makes possible the next step - innovative development of new products, interesting for high-tech market, at least national. We expect soon a progress on this way. In addition to new skills, the BY-NANOERA training program and conference visits kept INP BSU team in the mainstream of world science trends. Note that BY-NANOERA visiting program initiated development of similar programs with new partners, strengthening in such a way the BY-NANORA impact. Repeated visits of D. Bychanok, A. Paddubskaya, A. Pliushch, M. Shuba, N. Volynets, and others to INFN, TUB, HELAS, Imeh-BAS consortium members, as well as to our partners in Latvian University, Vilnius University, Eastern Finland University can serve as examples. Thus, INP BSU team initially originated from a theoretical group, becomes a well-balanced research unit with superior level in theory and good experimental experience.

In general, NEM introducing and development in INP BSU and rich experience of the project core team in international cooperation serves as a success story for many small- and mid-size Belarusian research teams orienting them on the participation in INCO programs as a tool for reaching success on the national level, and, what is more important, giving them a realistic example. What is why the BY-NANOERA project is potentially beneficial for Belarus research institutions working in electrical engineering, material science, condensed matter physics, and, even in the higher degree, to Belarus universities organizing research and education in the nanoscience and nanotechnology. At the output of the project we see appearance in Belarus a highly qualified research unit comprising both internationally recognizable experts and well-motivated young researchers in the field of science and application of nanostructures and, in particular, in applied NEM. The team is highly competitive on the international level to provide significant contribution into national RDT programs as well as into horizon 2020 Calls and other INCO programs. The success at the output is measured in terms of involvement into research projects with worthy of finances and frontier goals. Providing to the team members respectable status in the Belarus scientific
community and on international level, such a success has additional social impact as a successful story for many other teams in Belarus and, especially, for young generation of researchers. As a matter of fact, we see this effect even today, using it as a precondition of the project application: on the local level, in the INP BSU team, we succeeded in reducing brain drain rate.

In Belarus, the RTD system is based on well-trained and sufficiently large research staff concentrated mainly in National Academy of Sciences and in the high-education system. The staff originates from the FSU time and currently under strong effect of the brain drain. Research in frontier research field - nanoelectromagnetics - is very attractive for young generation of scientists. What is why on local level, in the INP BSU team, we do not see catastrophic consequences of the brain drain: undergraduated students willingly enter the team for writing diploma theses. Many of them continue the work as master and PhD students. The BY-NANERA project essentially strengthened motivation of young scientists for coming into team due to the following:

Opportunity for world-class research work with access to present-day experimental equipment and publications in high-ranked specialized journals high professional mobility allowing acquisition of new knowledge and skills in partners teams during training visits opportunity for the fast career development: in-time defense of PhD theses, availability of postdoctoral positions in partners' teams and in other institutions due to attractive and competitive CVs, competitiveness on the internal research job market.

Superior training in preparation of a good ppt presentation, developing of a profile and CV, skills of oral presentation, partner search and negotiation, proposal writing, and, to some extent, commerce and marketing skills typical for innovation activities.

Thus, the project brought new research experience to young participants unavailable at their home institution and new motivation for the work in the home institution: better work conditions, access to research infrastructures, better career opportunities due to high rating of the research field and competitive experience provided by the participation in the project and supplemented programmes on national and international levels. The above can be considered as an important societal implication of the project.

II. New projects and proposals initiated by BY-NANOERA

Being an essential dimension of the RTD policy, international cooperation is actively involved in realization of the policy tasks and, in turn, contributes into EU INCO activity and into ERA. As one of the main result of the project is preparation of several submissions into FP7/Horizon 2020 Calls by INP BSU team both in collaboration with the consortium members and with new partners found during the project implementation. Three new FP7 project started recently (or will start in 2014) due to collaborative links initiated by the BY-NANERA project:

Fundamental and Applied Electromagnetics of Nano-Carbons, EU FP7 project FP7-318617 FAEMCAR, Call ID FP7-PEOPLE-2012-IRSES, 2012-2016, Principal Researcher: Ph. Lambin (University of Namur, Belgium), team leaders: Y. Banis (Vilniaus Universitetas, Lithuania), S. Bellucci (Istituto Nazionale di Fisica Nucleare, Frascati, Italia), L. P. Biró (Research Centre for Natural Sciences, Hungarian Academy of Sciences, Budapest, Hungary), L.A. Chernozatonskii (Institute for Biochemical Physics RAS, Moscow, Russia), G. I. Dovbeshko (Institute of Physics, NASU, Kiev, Ukraine), P. Kuzhir (INP BSU).

Carbon-nanotube-based terahertz-to-optics rectenna, EU FP7 project FP7-612285 CANTOR, Call ID FP7-PEOPLE-2013-IRSES, 2013-2017, Principal Researcher: M. Portnoi (University of Exeter, UK), team leaders S. Maksimenko (INP BSU), G. Slepyan (Tel Aviv University, Israel)

A COST proposal “Nanoelectromagnetics facing societal challenges” has been submitted by a consortium of our partners headed by Dr. S. Bellucci (INFN) and is under evaluation. Belarus is not a COST member, but we hope for an active participation in the project in the case of its approval due to support of our partners. FORTH, TUB, Imech-BAS, Université de Lorraine, University of Latvia, Vilnius University, University of Eastern Finland, Tel Aviv University are partners. The main goal of the proposal is to provide sophisticated theoretical background and comprehensive experimental study of EM problems, including EM compatibility of ND and elements, at the nanoscale, and to provide effective knowledge exchange between participating teams reaching synergetic effect. Different nanoscopic devices, elements and materials will be investigated, both theoretically and experimentally, in a wide frequency range from RF to optics.

A new proposal for GRAPHENE Flagship Call with Prof. Philippe Lambin (University of Namur, Belgium) as coordinator is under preparation and will be submitted soon. The INFN, Imech-BAS and INP BSU teams from By-NANOERA participate in the proposal.

The application ”Graphene / carbon based ultra-light and thin electromagnetic shielding materials” has been submitted to NATO Science and Security Program with Prof. A. Celzard (University of Lorraine, France) and Dr. P. Kuzhir (INP BSU) as co-directors and INFN, Vilnius University (Lithuania) and Nikolaev Institute of Inorganic Chemistry (Novosibirsk, Russia) as partners. The ultimate goal of the project is to develop physical, chemical and technological basis for the design of new generations of ultra-lightweight and ultra-thin materials providing, depending on their secure applications, efficient absorption/shielding of electromagnetic (EM) radiation in a wide spectral range together with other important physical properties on a basis of three types of carbonaceous structures (i) nanometre-thin graphene-like films (ii) lightweight polymer composites containing hollow microspheres and carbon of high surface area, and (iii) porous ultra-lightweight carbon micro and nano foam (gel) structures for EM field isolation of both integrated circuits (ICs) and transport units, protecting data and secure information in portable electronic devices, computers, information and communication systems, as well as protecting individuals from EM pollution.

A new impact initiated by BY-NANOERA we expect from the NATO advanced research workshop (ARW) "Fundamental and applied nanoelectromagnetics". Application has been submitted in October 2013 and is currently under evaluation. The ARW is co-chaired by Prof. A. Maffucci (University of Cassino, Italy) and S. Maksimenko. The ARW is planned to be joined with the Korea-Belarus joint seminar on physics and devices of functional nanostructures, finally approved for financing by the Korean National Research Foundation. The direct contact to Korean researchers has been established during Nano electromagnetics session at Nanomeeting 2013 (May 2013, Minsk, Belarus). As prospective direction, we plan to organize a series of FANEM conferences on biennial basis. In the case of the COST proposal success, the next conference are planned to be organized in 2016 as a COST action.

However, this is not the only result directed to enhanced participation of the Belarus in the FP7. On the international level, the BY-NANOERA project provided us with extremely important contacts with leading teams working in the close fields, such as condensed matter physics, electrical engineering, material science, chemistry of nanostructures, and dealing with nanoscale objects and systems.

In more far perspective we expect essential interest to and, correspondingly, strong impact of the NEM Prognosis onto the research methodology and priorities for the future progress in NMP. As the example, formulation and initial investigation of the electromagnetic compatibility problem on nano-scale will result in essential modification of basic principles of high-frequency nanoelectronics and optoelectronics. We hope that our start-up research will reinforce the role of Belarus experts in coming Horizon 2020 Calls.

III. The use and dissemination of foreground
The main mechanism for dissemination of the project results and knowledge exchange with partners at national and international level is formed by the scientific network established during project realization. Outside the network the dissemination activity is concentrated within a program of coming conferences and workshops, either organized by INP BSU team (like FANEM second and subsequent editions or Belarus-Korea seminar in nanoscience and nanotechnology or future COST actions) or planned for attendance and special session organization.

Internet and national public and scientific media (articles) also serve as a channel to disseminate information on the BY-NANOERA project activities. A serious interest to BY-NANOERA was demonstrated by national massmedia during FANEM’12, see FANEM’12 presentation.pdf as supplementary material.

The INP BSU Strategy comprises a set of concrete actions (Activity plan) which should be realized in the next following years and give orienteer for the period till 2020.

List of Websites:

Project website: [http://www.nano.bsu.by/](http://www.nano.bsu.by/)

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