Long-range plan of Polish nuclear physics in the years 2007 - 2016

Introduction

Polish nuclear physicists are mainly involved **in fundamental research,** development of which is of great importance for future applications and for education of young generations of scientists that in the course of time will take the lead in the field of nuclear technologies in our country. Nuclear physicists in Poland have always recognized the need for contributing to nuclear physics applications.

On the global scale, Polish nuclear physicists participate in many large, European projects, which grant the highest standards of scientific investigations. Very often they play leading role in these collaborations - it can be certified by high number of citations of articles published in well-known international journals. Polish theoretical nuclear physics, supporting experimentalists in the data evaluation process and showing new research directions, play also the leading role in Europe.

Nowadays the most important experiments are performed at the SIS accelerator at GSI (*Gesellschaft für Schwerionenforschung*) in Darmstadt, at COSY in Jülich, at the GANIL (*Grand Accelerateur National d'Ions Lourds*) laboratory in Caen (France), at the ALPI accelerator in Legnaro (Italy), at JYFL in Jyväskylä (Finland) and at ZIBJ in Dubna (Russia).

Experiments in the field of nuclear physics are in part performed using the **HEAVY ION CYCLOTRON** at ŚLCJ UW. However, this cyclotron to deliver heavy ion beams needs improvement - it is necessary to equip it with the new generation ion source (ECR), as well as to perform progressive modernization of the intensively used all acceleration facilities.

For Polish scientists, the most interesting European project is the **FAIR** project – *Facility for Antiproton and Ion Research* – at GSI in Darmstadt. Considering scientific and technical reasons, the FAIR project is one of the most ambitious global programs. Its full cost is planned for 950 million Euros – 80% of the sum will be covered by the German government. The scientific studies at FAIR will be conducted in five main areas of physics:

1) nuclear structure physics and nuclear astrophysics with the use of radioactive beams;
2) hadron physics with antiproton beams;
3) hadron matter of high density;
4) plasma physics of high pressure and temperature;
5) atomic physics and its applications.

In the FAIR project, the most advanced technology will be employed - it should allow for parallel running of several experiments. The universal character of FAIR will make GSI the main scientific center of European nuclear physics for the next decades.

Second ambitious project, involving a large group of Polish physicists, is the **SPIRAL 2** project (*Systeme de Production d'Ions Radioactifs Acceleres en Ligne 2*) at GANIL in Caen. SPIRAL 2 is a French initiative (financed by French government in amount of 135 million

Euros) of global range. For the production of radioactive beams, a linear low energy accelerator will be used. The SPIRAL 2 project should be started in 2011 and will provide radioactive beams basing on the ISOL method (*Isotope Separation On-Line*). The beams will be used for nuclear structure and nuclear astrophysics investigations, as well as for the studies of new symmetries. This project has a strong support of European bodies because it is a predecessor for EURISOL – a large European project – planned for the year 2016.

In the nearest future, other possibilities for the Polish nuclear physics at relativistic energies will be offered by the large hadron collider LHC at CERN. It will be done mainly by using the **ALICE, CMS** and **ATLAS** detectors, built with the contribution of Polish boards. The objectives regard investigations of quark-gluon plasma produced in relativistic heavy ion collisions in the TeV energy range. Nowadays, similar works, but at much lower energies than planned at LHC, are conducted on **RHIC** accelerator (USA).

Among nuclear physics experiments which do not require accelerated beams, we have to mention the search for neutrino-less double beta decay. This kind of measurements, which are performed in the underground laboratories with low natural background, may give us the information on basic properties of neutrinos. The interest of Polish nuclear physicists concentrates on the participation in construction of SuperNEMO (Frejus) and GERDA (Gran Sasso) detectors. We plan also to start the Polish project of the low natural background laboratory. This would be done with the use of chambers with unique physico-chemical properties in the old copper mine in Sieroszowice-Polkowice.

The theoretical investigations on nuclear physics are distributed among many academic centers, similarly as it is organized in other countries. On the European scale, the Polish theoreticians play a very important role in the activity of the European Center for Theoretical Studies (ECT) in Nuclear Physics in Trento.

Radioactive isotopes, high-energy proton beams and heavy ions play vital role in medicine - in diagnostic and treatment of various diseases, particularly oncological. Consequently, the support for research projects aiming at applications of nuclear methods in medicine and the increase of funds for those projects should be of primary importance. One of the most significant projects is the Proton Therapy Center in Cracow. At this Center, located at the Institute of Nuclear Physics PAN (IFJ PAN), the development of proton radiotherapy of the eye melanoma is already advanced. Also, the construction of the Center of Positron Tomography at ŚLCJ in Warsaw is moving on. These centers are very important both for the development of new medical diagnostic methods and for carrying out research in large scale of “life sciences”.

It is inevitable that in the nearest future Poland, taking care of its energy self-dependence and of ecology, will have to introduce nuclear energy on the large scale. Recent events proved that Poland cannot be secure with respect to energy self-dependence. Therefore, to improve the safety, the construction of nuclear power plants is necessary. Polish science – particularly nuclear physics – may support the decision process by preparing various experts reports, education of high-qualified specialists and education of the society. Nowadays we have to think about future technologies, which assume among other issues the construction of IV generation of high-temperature reactors. Preliminary studies on the above-mentioned reactors have been started at the Environmental Heavy Ion Department (ŚLCJ) of Warsaw University, at the Faculty of Physics and Applied Computer Science AGH, etc. The aim of the research program is the construction of the appropriate installations in Poland, about the year of 2015.

Deeper investigations on the thermo-nuclear reactors have been undertaken. The Institute of Nuclear Problems and the Institute of Plasma Physics and Laser Micro-synthesis actively participate in the project of the European ITER reactor – it is being done in the frame of the EURATOM program.

Below are presented the long-range plans regarding the development of Polish nuclear physics and the engagement of Polish physicists in the large, European research projects for the years 2007-2016. Included are also large projects associated with the use of nuclear physics technologies in medicine, biology and interdisciplinary investigations, and in the studies on nuclear energy and its surroundings.

Institutes introducing scientific research on nuclear physics:

Scientific institutes:

1. The H. Niewodniczański Institute of Nuclear Physics of the Polish Academy of Science (IFJ PAN),
2. The Andrzej Sołtan Institute of Nuclear Problems (IPJ)

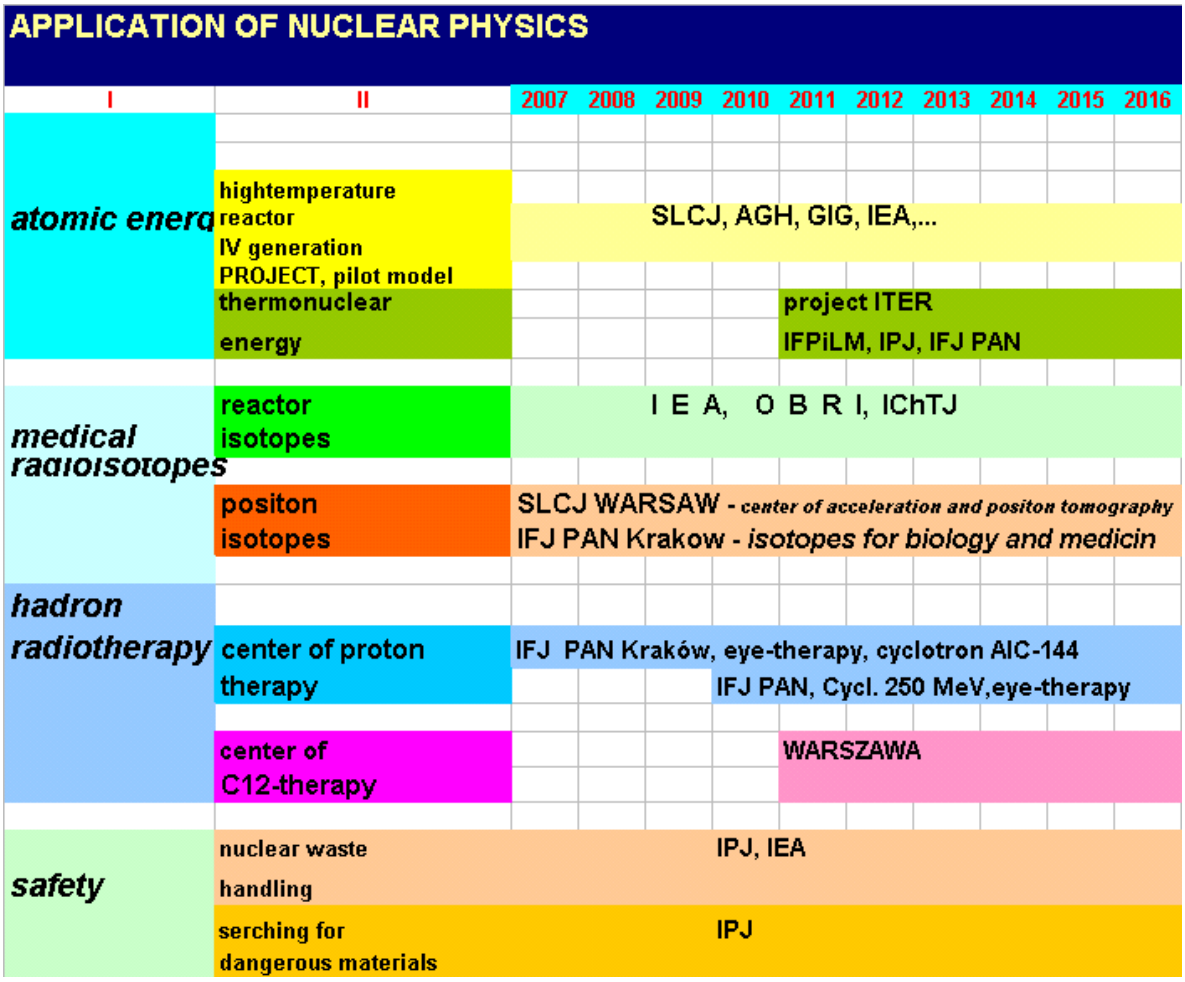
Universities:

1. Jagiellonian University (UJ)
   - Faculty of Physics, Astronomy and Applied Computer Science
2. Warsaw University (UW)
   - Department of Physics
   - Environmental Laboratory of Heavy Ions (ŚLCJ)
3. The Maria Curie-Skłodowska University (UMCS)
   - Department of Mathematics, Physics and Computer Science
4. Warsaw University of Technology (PW)
   - Department of Physics
5. AGH University of Science and Technology (AGH)
   - Department of Physics and Applied Computer Science
6. Silesian University
   - Faculty of Physics
7. University of Łódź
   - Faculty of Physics
8. University of Zielona Góra
   - Faculty of Physics and Astronomy
9. Świętokrzyska Academy
   - Faculty of Mathematics and Natural Science
10. Wrocław University
    - Faculty of Physics and Astronomy

LONG-RANGE PLAN
OF POLISH NUCLEAR PHYSICS (2007-2016)
(Theory and experiment)

BASIC RESEARCH

I	II	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
structure of atomic nuclei and nucleon-nucleon interactions	exotic nuclei	SPIRAL2									
		FAIR									
		SIS@GSI									
	nuclei in extreme conditions	SPIRAL2									
		FAIR									
		Legnaro, Jyvaskyla, RIA									
	structure of excited states	SLCJ									
		FAIR									
		SPIRAL2									
		Legnaro, Jyvaskyla, RIA									
	weak processes	underground low background lab (Sieroszowice)									
nuclear matter	quark-gluon plasma	ALICE@LHC CERN									
		RHIC			FAIR						
	hadron matter	FAIR									
		SIS@GSI									

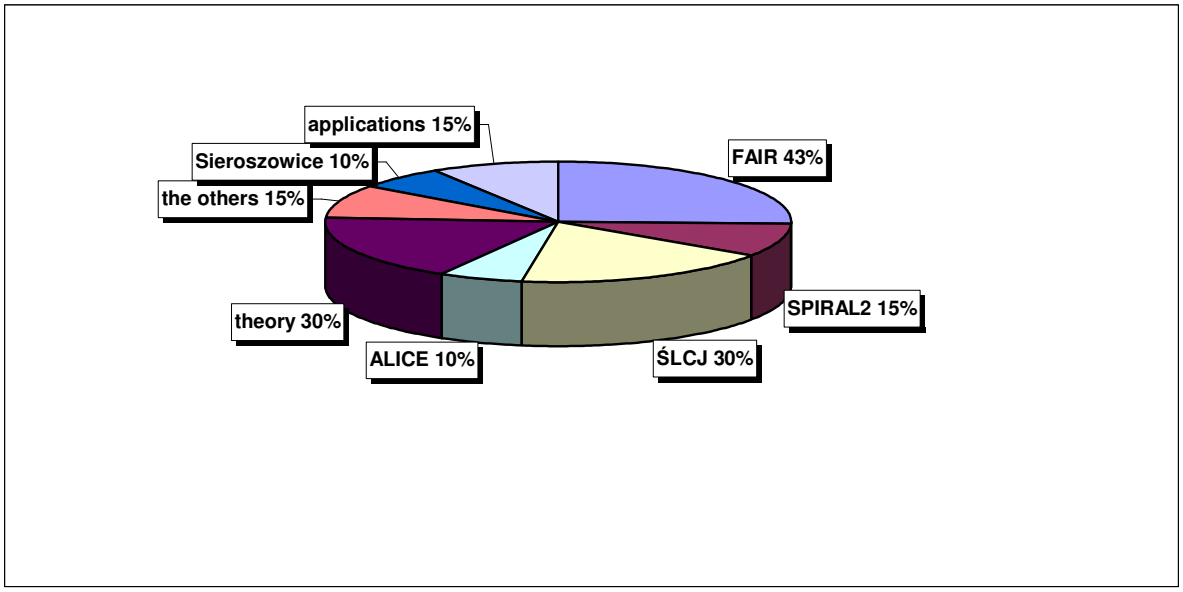


Expenses on the facility investments in application physics should be transferred from **structural funds**. For this purpose the questionnaires prepared by the following institutions will be delivered:

ŚLCJ – Environmental Heavy Ion Department
IFJ PAN – Institute of Nuclear Physics of the Polish Academy of Sciences
IPJ – Institute of Nuclear Problems
AGH – AGH University of Science and Technology
GIG – General Institute of Mining
IEA – Institute of Atomic Energy
IFPiLM – Institute of Plasma Physics and Laser Micro-synthesis
OBRI – Research and Development Center of Isotopes (POLATOM)
IChTJ – Institute of Chemistry and Nuclear Technology

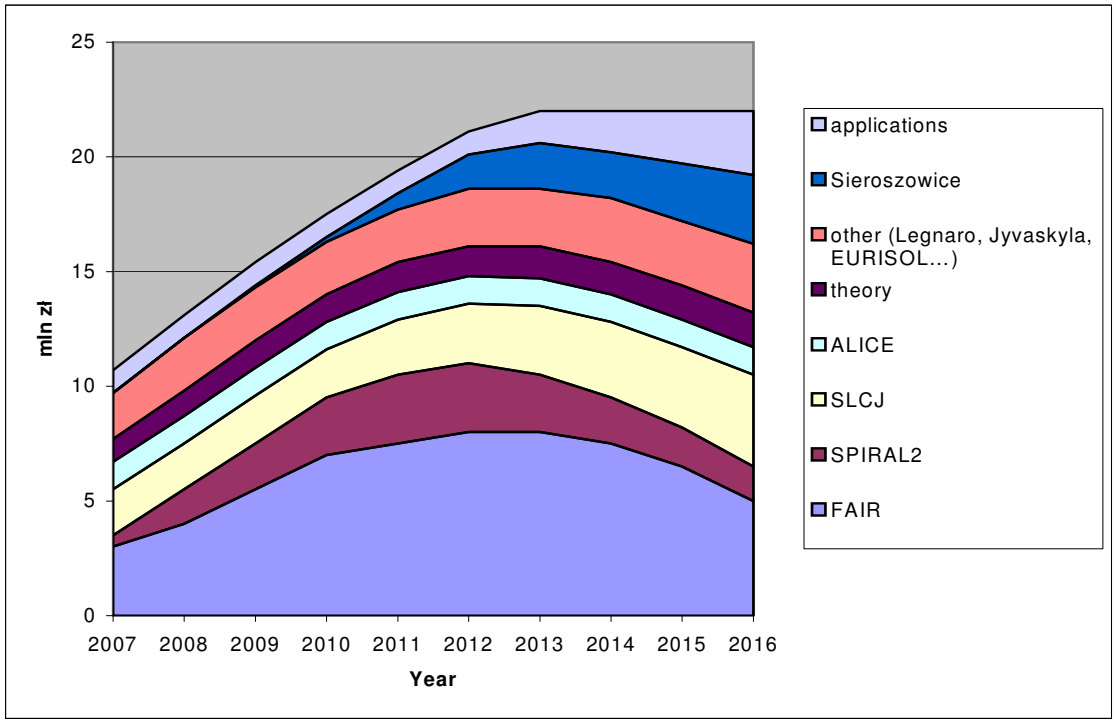
PLANNED AVERAGE STAFF INVOLVEMENT

Number of scientists involved in particular projects – full time employees



THE OUTLINE OF BUDGET EXPENDITURES

The predicted research costs of particular projects do not include the funds granted to the institutes in the frame of subjective allocations.



The enclosed long-range plans of Polish nuclear physics for the years 2007-2016 are prepared by the Commission of Nuclear Physics by the Atomistic Advisory Board:

Prof. Dr. Jan Styczeń (IFJ PAN) – chairman
Prof. Dr. Jerzy Jastrzębski (ŚLCJ UW)
Prof. Dr. Marek Jeżabek (IFJ PAN)
Prof. Dr. Reinhard Kulessa (IF UJ)
Prof. Dr. Adam Maj (IFJ PAN)
Prof. Dr. Zbigniew Majka (IF UJ)
Prof. Dr. Tomasz Matulewicz (IFD UW)
Assoc. Prof. Paweł Olko (IFJ PAN)
Prof. Dr. Krzysztof Pomorski (UMCS)
Assoc. Prof. Grzegorz Wrochna (IPJ)
Prof. Dr. Wiktor Zipper (UŚ)

Kraków, 20 September, 2006