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Development of free electron laser and accelerator technology in Poland (CARE and EuCARD projects)

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ABSTRACT

The development of accelerator technology in Poland is strictly combined with the cooperation with specialist accelerator centers of global character, where the relevant knowledge is generated, allowing to build big and modern machines. These are relatively costly undertakings of interdisciplinary character. Most of them are financed from the local resources. Only the biggest machines are financed commonly by many nations like: LHC in CERN, ILC in Fermi Lab, E-XFEL in DESY. A similar financing solution has to be implemented in Poland, where a scientific and political campaign is underway on behalf of building two big machines, a Polish Synchrotron in Kraków and a Polish FEL in Świerk. Around these two projects, there are realized a dozen or so smaller ones.

Key words: accelerator technology, synchrotron, linac, free electron laser, FEL, radio frequency superconducting circuits, financing of research,

1. INTRODUCTION

EuCARD and CARE are examples of large European framework research and development programs to build common, enormous research and development infrastructure in the area of accelerator technology. CARE – Coordination of Accelerator Research and Development in Europe, was realized during 2004-2008, and EuCARD – European Coordination of Accelerator Research and Development, is its close continuation, and is planned for realization during 2009-2012. These programs consist of research networks, trans-national access to large research infrastructure and quite a number of particular joint research activities. The latter concern apparatus design methods, technology development, material research on materials, components, sub-assemblies, and considerable modernization parts of existing large infrastructure. Polish research and development community utilize the participation in these programs very efficiently for: exchange and training of researchers, increased participation in large experiments attracting young researchers to exciting and demanding topics, building of auxiliary infrastructure in Poland, access to new technologies and knowledge having industrial applications. Participation in large, global and European research programs is a strong stimulation for undertaking in Poland, our own brave programs of building accelerator infrastructure. Towards the end of 2007, the National Council of Nuclear Research, cooperating with the National Atomic Energy Agency recommended for realization (apart from the basic program of building of nuclear energy infrastructure) three big accelerator projects: Center of Hadron Therapy, National Center of Synchrotron Radiation, Polish Free Electron Laser – Polfel.

2. ACCELERATOR TECHNOLOGY

Accelerator technology is a branch of research and technology which subject is acceleration of charged particles, research of the beams, interactions between beams and technical applications [1-19]. It embraces theoretical aspects and technical associated with the beams, design and optimization of accelerators, building, exploitation, applications for research and technology; properties of accelerating particles individually and in beams; particle detectors; points of particle interactions; application of particle beams; electron and positron beams, muon (heave electron) and meson (two quarks) beams, proton and ion beams. The particles were accelerated to relativistic velocities, some time ago electrostatically (Van de Graaff), and now in EM RF accelerators. The accelerators can be warm, working in room temperatures, or cold, the latter working in liquid helium, usually below 2K. The electrical field intensity in a resonant cavity made of copper and tungsten of a warm accelerator may reach 200MV/m (typically below 100MV/m). The electrical field intensity in a resonant cavity made of single crystal niobium of a cold accelerator may reach above 45MV/m (typically around 30MV/m).

The ultimate confinement of the field value in warm accelerators are electrical breakdown and pulling out atoms from the metal surface in the resonant cavity. The surface of warm copper cavity can be hardened locally, in the most critical places, by covering it with tungsten. The field in cold cavities may be increased by application of very pure, single crystal niobium Nb instead of polycrystalline (as usually metals are). Other direction of development of cold cavities is looking for materials which are warm superconductors. A promising material is Nb_3Sn. The confinement for the largest field value is multipacting, or avalanche multiplication and acceleration of electron cloud pulled out form the metal surface. These electrons build up a parasitic dark current of the accelerator. Other confinement is existence of residual higher order modes (apart from the fundamental mode – which is used for acceleration) in the resonant structure of the accelerator. At the above values of the electrical field intensity, the deposit of EM power, in a form of standing wave is very large and may reach a few hundred kW per a single cavity. The aim of efficient acceleration is transferring of this large power, in the largest possible degree, directly to the electron or positron beam. The most popularly used cavities in the superconducting RF accelerators are of the TESLA type. They are made of pure niobium, work at the frequency of around 1,3 GHz, and in temperature below 2K. A single cavity consists of nine cells. Each cell is half-wavelength long, thus the whole structure is around 1m long.

Apart from application of large accelerating machines, there are developed alternative laser-plasma accelerating schemes for particles. An accelerating tunnel is created by a high power laser in dense plasma. The EM field intensity in plasma tunnel may be three orders of magnitude higher than in cold RF accelerators, and may reach tens of GV/m. This allows for generating of very energetic particle beams at the cost of considerable shortening of the accelerating structures and decreasing the overall needed energy, thus, increasing the machine efficiency. The problems to solve are: increasing the stability and length of the dynamic accelerating, plasma tunnel. Still another way to obtain ultra-high-energy relativistic particles is cosmic radiation. However, these particles are very rare events and are not controllable. The effects of their interactions may be observed.

The accelerators are also used for indirect generation of neutral particle beams, like neutrons and neutrinos, via the spallation of atom nuclei. The accelerator technology, via high energy of the particle beams, is closely related to nuclear technologies. It is also used, which is most interesting, for generation of photon beams of very wide spectrum of energies now from far IR, via visible to X rays and in the future to gamma rays. The machines to generate the most powerful photon beams are free electron lasers, using longer and longer linear accelerators, undulators and SASE mechanism. In this way, the accelerator technology is closely combined with photonics, optoelectronics, optics, electronics and mechatronics. Availability of more and more powerful user machines extracts a relatively new branch of research and technology called photon physics. These activities are one of the paths leading to the harnessing of a photon, in a similar way we have harnessed the electron. A photon is, however, much more difficult to be harnessed, because it continuously keeps escaping. There are a number of difficult problems, along this photonic path, to be solved, and among them: a considerable slowing down of the photon, if not stopping him completely for a while, gathering photons, controlled interaction of photons with the same and different energies, guiding of the photon along a complex optical path, optics of refraction equal to one, less than one, close to zero and negative. Especially the optics of negative refraction seems now very challenging in the visible spectrum.

3. INSTITUTIONS OF ACCELERATOR TECHNOLOGY

The development of accelerator technology, due to the character of experimental work demanding very large machines, is concentrated in few research centers around the globe. The biggest accelerator complex in the world is located in CERN [20]. Big accelerator center of national character are: Fermi Lab [21], SLAC [22], ORNL-SNS [23], Jefferson Lab-CEBAF [24], DESY [25], INFN [26], IN2P3 [27], KEK [28], etc. Research teams from Poland cooperate closely with these laboratories in Switzerland, France, England, Germany, USA and Japan. A considerable number of young scientists stays there permanently on shorter or longer research fellowships. A number of them keeps tight relations with the country by carrying common research projects. The accumulated experience, knowledge, cooperation between large teams, carried technical debates, participation in common programs, gives with time the birth to brave ideas to build large accelerator infrastructure in Poland. The ideas, worth hundred million zł, of this kind, are: Polish Synchrotron [29] in Kraków, and Polish Free Electron Laser – POLFEL in Świerk [30]. Realization of such big projects in this country is important from many reasons – active participation in the process of generation of knowledge, breeding of new generation of scientists, generation of technical applications, etc.

European coordinator of accelerator research, on the administrative level, is ESGARD – European Steering Group for Accelerator Research and Development [31]. The Group consists of directors of international and governmental institutes of nuclear and accelerator technologies in the UE countries which have their own big accelerator infrastructure. Poland has not a representative in ESGARD. The natural candidates are directors of the IPJ in Świerk [32] or IFJ in Kraków [33]. Other organizations may also be taken into account, as governmental institutions like IEA or PAA – National Atomic Energy Agency. The condition, to have a representative in ESGARD is to possess in particular country active accelerator infrastructure. Poland has not such an infrastructure now of considerable extent. A cyclotron is in possession of Heavy Ion Laboratory by Warsaw University [34]. Some time ago there were active small electron linacs. This infrastructure will not be modernized, possibly only as part of bigger undertakings. Such plans are related to the mentioned national synchrotron and fel laboratories. Participation in ESGARD activities is very important for the national research and technical communities. This influential organization takes actively part in crucial decisions, preparations, and submission of research programs in this area, covering the whole Europe.

European coordinator of accelerator research, on the scientific level, is ECFA – European Committee on Future Accelerators [35]. The members of ECFA are professors, representing research institutions from the EU member states, which carry out research in the accelerator technology. Poland is represented by a representative of IPJ. Poland, as a member of CERN, is also represented in ICFA – the International Committee for Future Accelerators [36]. A part of the coordination activities is done by the International Union of Pure and Applied Physics IUPAP [37]. Poland is represented in IUPAP by a representative of IF PAN. The ECFA cooperates with analogous regional organizations like Asian ACFA [38] under the umbrella of ICFA which has more global extent.

The most important developmental factor for accelerator technology (and for other branches of research and technology) is existence in Europe of a relevant, lobbying, strongly organized, research and technological community, representing the activity area on the governmental, organization, financial, business, scientific, industrial and social levels. Participation of Poland in such big, strictly organized and coordinated in the scale of whole Europe, research programs requires the existence of analogous communities – actively interacting with the European ones.

The listed factors of existence of centers of influence are fulfilled in relevance to the European community of accelerator technology. In Europe, and in most of the countries interested in the participation in the accelerator technology programs, there exist relevant institutions, organizations and governmental bodies, as well as professional and community groups. A similar situation is in Poland. The governmental bodies are PAA –National Atomic Energy Agency [39] and interested governmental ministries. The professional bodies are topical consortia, research networks, centers of excellence, industrial clusters, technological platforms – which are sides of big experiments. Other relevant institutions are units of PAN [40] and professional associations, like: Committee of Physics, Department III of PAN, Department IV of PAN – Technical Sciences, Polish Physical Society [41], Polish Society of Synchrotron Radiation [42], Polish Nucleonic Society [43], etc. The professional work force originates from several PAN and JBR institutes like: IFPiLM, ICHiTJ, IPJ, IFJ, IEA, ITME, ITE, IF-PAN, MITR-PŁ, etc. Among the national universities, AGH features the widest participation in the international accelerator experiments.

The usual place of meetings of the international accelerator communities are conferences: PAC, EPAC [44], LINAC, FEL, ICALEPCS [45], etc. Proceedings of these conferences are published on a common, global Internet web portal JACoW – Joint Accelerator Conference Web site [46] or CERN portal INDICO – International Digital Conference [47].

4. FINANCING OF ACCELERATOR TECHNOLOGY

Big accelerator structure is financed generally on the level of relevant countries. Similar situation is in the case of different infrastructural investments like: space research, nuclear or large power utilities. Despite the national character, in most cases, the big infrastructure is open and made widely available for international proposals from research teams, nearly without any confinements. A separate issue is financing of these proposed experiments by directed grants. Only the biggest world experiments are financed for infrastructure fully by international research consortia. The kinds of costs have to be differentiated: direct infrastructure investment, basic maintenance, experiment maintenance, excess costs of particular experiment, etc. Similar solutions have to be assumed in Poland. The two mentioned projects have to be realized mostly from own resources. Simultaneously the managers of the projects have to look for a reliable and the widest possible international partnership. The partners are absolutely necessary, because at such complex and technologically advanced undertakings, not all necessary knowledge is available in a single country. New national research teams are trained extensively around such projects. Despite the creation of a new infrastructure, the international cooperation assures effective usage of the available exploitation time of the machine. The large and expensive infrastructure has to be of a double usage: research and user oriented. Marrying of these two functions is not an easy logistic task which has to be mastered by the machine managerial team. Financing of such big and unique infrastructure now in Poland uses an outdated method of SPUB type of grants. The method is not optimal for building large machines in wide international cooperation, where the endeavor extends the frames of a single institution, even the frames of several joined specialist national institutions. The infrastructure of this size has to be inbuilt into an international network of similar machines.

Since the access of Poland to the EU, a possible source of co-financing for large research infrastructure are the European structural and framework programs. It means a co-financing and not full financing, because a very good program definition and a declaration of own financial input are necessary. Structural programs of EU (POKL, POIG, POIS,...) and the successive FP7 are a natural source of co-financing for these two programs of the Synchrotron and the FEL. FP7 was planned for 2007-2013 as a continuation of the previous FPs. Technical information is available via Cordis [48]. Polish laboratories participated in FP5 during the pre-accession period and in FP6 (2003-2008) after the accession. The budget of FP7 is around 50Mld€ which is around 5% of the accumulated research budget of EU and separate budgets of the member countries. At this budget, influence of the program is planned mainly in the regions of focusing and amplification of the European integration in the research area, building of the ERA, investment in the human resources, amplification of mobility schemes, searching for directions to increase Europe's competiveness in innovative industries – strongly based on research, evolutionary building of knowledge based information society. FP7 is divided to large sub-programs: People – embracing investment in human resources including young researchers; Ideas - investment in innovative projects by European teams and building of European Council for Research; Cooperation – (the largest part of FP7) building of modern methods of trans national cooperation combined with coordination of national efforts and building of European Technological Platforms; Capacities – development of research infrastructure to rise the European research and innovation potential. These programs are amplified by building a Joint Research Centre [49] to improve the common research policy; and creation of Euratom – European Community for Atomic Energy [50].

Capacities – FP7 part concerning the infrastructure, has a budget of over 4Mld€, (600M€ per annum) which is relatively small in the European scale. Its impact may be visible only when the financing is strictly directed to narrow and the most demanding aims. Maximum co-financing of a single grant is 10M€. Topical definition of the program is strictly determined by on the political level by the ESFRI – European Strategic Forum of Research Infrastructure [51]. Poland participates in the activities of ESFRI by the representatives of the NCBR – National Center for Research and Development [52] and the Ministry of Research and Higher Education. Capacities is divided to a few priorities, from which two the biggest are: research infrastructure (1,7Mld€) and SME (1,3Mld€). EU defines the research infrastructure as: devices, resources and services to carry valuable basic research, and to disseminate, exchange and store the generated knowledge as results of these experiments. The research infrastructure embraces: research machines, archives of information, telemetric networks (GRID, GEANT), unique research structures. Research infrastructure is a tool in building e-science. The main components of e-science are: a researcher, an experiment and storage, analytic and processing of information. The research infrastructure fills the area of a triangle of science, with the edges made of research, education and innovation. The general non-topical priorities (topical priorities are defined by ESFRI) of EU concerning the research infrastructure are: usage optimization, development of the best existing infrastructure, help in building the new needed infrastructure of pan-European extent, amplification of trans-national processes in creation and usage of infrastructure.

The scale of realization of an individual research program of global extent inside the FP7 program is not directly expressed by the accumulated financing. The components are: participation declaration from the industry, additionally generated industrial contracts, rejuvenated trans-national activities, synergetic effects, number and quality of institutions affiliated with the program, interest of young researchers, predicted results of the program realization, interest in these results by research, governmental, business and industrial communities, and many more. In certain cases, the best ones, with many industrial contracts associated with the program, the financial multiplication of the program investments, of big predicted impact for industry, may be estimated for 2 -3. It means that in the case of EuCARD program the accumulated, virtual investment is of the order of 100Mln€. The chances to approve a program of this size are associated with several key factors. One of these factors is a declared level of own financial participation. Theoretically the obligatory level is 25%. The declaration from EuCARD was around 70%.

5. CONSORTIA, NETWORKS AND TECHNOLOGICAL PLATFORMS OF ACCELERATOR TECHNOLOGY

Examples of Networking Activities (NA) and consortia in accelerator technology are (FP6): ELAN – European Linear Accelerator Network [53], BENE (MEGLIO) – European Beams for Neutrino Experiments [54], HHH- high energy, high intensity hadron beams [55], EuDET – Detector for ILC [56], FITAL – Consortium of Physics and Technology for high energy Linear Accelerators [57], Femtophysics, CEAT – Center of Nuclear Technologies. Such consortia and networks in Europe and in Poland are opened for particular purposes. Some of them like EDET or FITAL, and Femtophysics are closely associated with global experiments like ILC – International Linear Collider [58]. Research teams from Poland participate in most of these consortia and networks. A general assumption for NA is building of cooperation culture between participants and communities using the common infrastructure. It is realized by activities on behalf of: users (training), communities (conferences, working groups), good research practices (exchange of personnel, work standards), trans-national access (TA), intensifying of common research activities, building of virtual infrastructure (data and software). The aim of TA is to provide the possibility or a real and virtual training of personnel, and optimal usage of the infrastructure. The aim of joint research activities JRA is the development of prototypes, methods, protocols, standards, software, providing of samples for research.

TESLA Technology Collaboration (TTC) [59] is a continuation of TESLA Collaboration. The aim of the latter was building of a planned linac and electron – positron collider – Tera-ElectronVolt Superconducting Linear Accelerator, located in DESY. Now the project was shifted to other location and is continued by the Fermi Lab. The TTC was evolutionary transformed into an important consultative body of global community character. Participation of a numerous research teams from Poland in the research programs of CARE and EuCARD resulted in acceptance of Warsaw University of Technology and Łódź University of Technology into this influential body of global character. The members in TTC are also Polish atomic institutes.

Potential participation of Poland in the ILC – International Linear Collider project is quite wide, and may embrace even a few hundred of the personnel. Numerable research teams from Poland have recently declared their interest in the work on design, construction and usage of this enormous linac, detectors and accompanying infrastructure. Some of the teams proposed a number of innovative research experiments using this machine. The coordination of activities on ILC in the wide scale is done by the GDE – Global Design Effort. To facilitate the cooperation with the GDE, the ILC communities in Poland have recently organized themselves into several topical consortia like: EuDET, FITAL, Femtophysics and other like Warsaw ILC Group [60], Warsaw E-XFEL Group, Warsaw ELHEP Group – Electronics and Photonics for High Energy Physics Experiments [61]. The project of ILC will belong to the largest research undertakings besides ITER [62] and LHC [63], with the total budget over 10Mld€.

The biggest in the world, working now, free electron laser FLASH is located in DESY/Hamburg. The laser uses a two hundred meter electron linac based on superconducting TESLA technology [64]. FLASH laser is generating a beam of VUV photons, the most intense ever. It is mainly a user facility. In parallel, it serves as a machine study and development laboratory for the planned European Roentgen E-XFEL Laser [65]. The linac for E-XFEL will be around 2 km long, i.e. ten times bigger than in FLASH. A large number of research teams from Poland participate in the development of both lasers, and in the programs of beam usage.

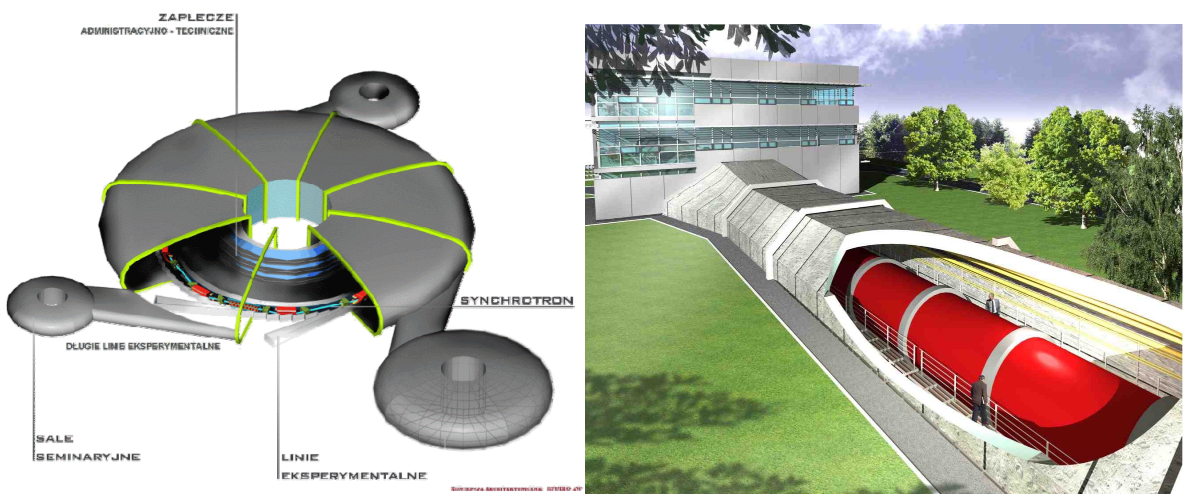
A consortium XFEL-Poland was inaugurated in 2007 [66] to facilitate and coordinate the cooperation with E-XFEL. Construction of this large machine will be done on commercial basis by the E-XFEL-G.mB.H. The partners of this business will be nondependent daughter firms E-XFEL-country. Here in this country, the partner will be E-XFEL-Poland Sp.z.o.o. A partner of this firm will be NCBR. A large number of European countries have declared participation in E-XFEL. The share is declared in a percentage of the total costs, which are now evaluated for around 1,5Mld€. Poland has initially declared, on the governmental level, a share of 30Mln€. This amount defines also a percentage of the future machine ownership. The share may be declared in cash as well as in-kind. The In-kind contribution embraces personnel and materials.

In parallel to the activities of the E-XFEL-Poland, during the same time and basing on similar rules, there was established a consortium on Femtophysics [67]. The aim is to prepare in Poland a relevant research and experimental structures for efficient cooperation with the international accelerator center for anti-proton and ion research FAIR GSI in Darmstadt [68]. This center possesses one of the biggest accelerator infrastructures in Europe. It does research on the structure of matter and evolution of the universe. The participation of research teams from Poland is quite numerous. The financing is provided on the governmental level.

POLFEL project [30] is closely combined with FLASH and E-XFEL, research and user projects realized in DESY. Polfel laser is designed as a part of a big European network of FEL lasers, cooperating with the biggest E-XFEL machine. It will be realized in IPJ Świerk. The total cost is estimated now for around 100Mln zł. The realization time is estimated for a decade. Polfel will use superconducting cavities organized in cryo-units of TESLA type. Each unit has eight cavities. The source of electrons will not be pulsed (klystron) but tunable CW (klystrode) [69]. The construction and exploitation of the machine will engage a large number of research and technical teams from the whole country.

Polfel is a part of a planned Research-Technology Park by the National Center of Atomic Energy CEAT. This large project engages the biggest institutes of atomic technologies, local government, universities, PGE - Polish Electrical Power Group, public and private businesses. The project consists of the activities of Polish Technological Platform for Nuclear Technologies [71]. The CEAT was established as a research and development consortium and one of its tasks is training of personnel for atomic industries [72] embracing also accelerator technology. Further plans combined with the development of this large research and industrial center is to establish a new university – MAT - Mazovian Academy of Technology, teaching engineers in modern branches like accelerator technology, nuclear energy industry, atomic technologies for industry, medicine, environmental protection and safety.

Polish Synchrotron [29] is a very important project to built in Poland a strong, research and technical, as well as industrial center of synchrotron radiation. Till now, the strong national synchrotron radiation communities were realizing their projects abroad in: Cern, Desy (HasyLab), Triest, ESRF, Grenoble, Soleil, Orsay Lure, in Francji [70], or in USA. The most important aspects of this project are: teaching, technical and industrial.



Visualizations of synchrotron machine in Krakow National Center of Synchrotron Radiation (left) and POLFEL machine localized in the Świerk Park of Research and Technology (right)

Now, and during the closest years, the most important accelerator project in the global scale is CERN's LHC – large hadron collider and their detectors: CMS, ALICE, ATLAS, LHCb [63]. The participation of research teams from Poland is quite big. A few hundred people take part in the realization of the accelerator, the detectors and accompanying infrastructure. These personnel includes physicists, engineers and technicians. Now there is continued intensive work on the first synchronization of the whole 27 km long cold accelerating loop and trials to launch the first beam. The tests will be done with low intensity beam. The full operability of the LHC (with the full power beam), which searches for the Higgs boson, is predicted in two years time. Next, the upgrade for increasing the luminosity twice should immediately start. The unique experiences gathered by these teams are forwarded to other planned immense international experiments like SLHC, ILC etc. A particularly large team of experts from Poland took part in the design and construction of the CMS – compact muon solenoid detector. A team of physicists and IT engineers takes part in building of a global numerical calculations Grid for the LHC experiment. The project called POLTIER engages a dozen of national IT centers. Indirectly, with these experiments are associated networks of Polish Nuclear Physics and PSAC-Polish Network of Astroparticles.

6. FP7 IA EuCARD PROJECT

The debated FP7 EuCARD program was preceded by an analogous FP6 program CARE – Coordinated Accelerator Research in Europe [31]. CARE was realized in Europe during 2004-2008. The following research teams from Poland took part: Technical Universities form Warsaw and Łódź – working on the control system of the accelerator, Wrocław University of Technology – working on liquid helium systems, and IPJ – working on plasma sputtering of copper cavities with niobium. As a result of this participation, a modern ELHEP Laboratory of electronics and photonics systems for high energy physics experiments was established in the Institute of Electronic Systems, WUT. In these mentioned institutions a few Ph.Ds and D.Sc theses were accomplished from the research on accelerators. The same institutions, with the similar research teams and technical topice continue their participation in the EuCARD Program.

The EuCARD – European Coordination for Accelerator Research and Development program [73] was accepted by the EU in May 2008 for realization during the period of 2009-2012. It belongs to the FP7 Capacities group of programs and is associated with the rejuvenation and building of the community infrastructure in the area of accelerator technology. A very costly accelerator infrastructure, predicted mainly for fundamental research (as LHC and CLIC in CERN), as well as application research (as FLASH in DESY), in such branches as biology, medicine, material engineering, power, environment protection, safety, must be financed from the community, trans-national resources. The aggregated budget of the program (EU donation and own input) reaches around 35Mln€. The program belongs to a group of IA – Integrating Activities and consists of NA- network activities, TA – trans-national access and JRA – common joint research activities.

The EuCARD program of European accelerator technology is realized by a consortium of 40 research institutions: governmental, academia, and private ones, including the entities form Poland. A number of other associated institutions is combined with the program. The following country representatives participate in EuCARD: England, Austria, Finland, France, Spain, Malta, Germany, Poland, Russia, Switzerland, Sweden and Italy. The involved institutions are mainly universities or big governmental topical laboratories. The participants from Poland are Technical Universities from Warsaw, Wrocław and Łódź, and IFJ, IPJ.

The main aims of the program are: full usage of LHC accelerator potential, increase of LHC luminosity, development of CLIC accelerator, participation in ILC project development of high-intensity ion accelerators and accelerators for FEL lasers, etc. The main research subjects of EuCARD are: superconducting magnets of high field intensity, high temperature superconducting materials, materials and techniques for accelerator beam collimation, ultimate-gradient warm linear accelerators, superconducting RF technology, neutrino factory, alternative methods of particle acceleration and collimation. The realization of program topics is concentrated around the following European accelerator infrastructure: CERN in Geneva (LHC, SPS-CNGS, CTF3), INFN in Frascati (DAFNE, SPARCX), STFC/Cockroft in Daresbury (EMMA), GSI in Darmstadt (SIS, FAIR), DESY in Hamburg (FLASH, PETRA III, TTF), FZD in Drezden (ELBE), FZK in Karlsrue (ANKA), LOA in Paris (plasma accelerator), CEA in Saclay (SupraTech RF), LAL in Orsay (SupraTech RF), BESSY in Berlin (Hobicat), RAL in Oxfordzie (MICE).

7. CONCLUSIONS

- The national, research and technical community of accelerator technology has recently organized themselves in a number of consortia and research networks and technological platforms. Such a social self-organization is now required as these bodies are partners to analogous European structures building together relevant and big research programs. These bodies enable absorption of program funds from operational and framework programs.
- Participation of the research and technical teams from Poland in large European and world wide programs in accelerator technology is absolutely needed for the development of this technology in the country.

- The programs for accelerator infrastructure development in Poland now embrace three big planned projects: Center for Hadron Therapy, National Center of Synchrotron Radiation, Polish Free Electron Laser POLFEL.
- The success in acceptance and then realization of a big European research and development program depends in a big degree on the interaction strength of the national, topical communities, its lobbying influences, the way the community id self-organized, the way it is bound to the international community, etc.

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