Appendix to the communication of
the Minister for Science and Higher
Education
of April 12, 2018

Application for inclusion of a strategic research infrastructure project in the Polish Roadmap for Research Infrastructures

Project name:	**HIL@ECOS** **Extension of HIL for the ECOS initiative**
Applicant details: **1) name, registered office and address;** **2) full name of the head of unit.** *Where the application is submitted on behalf of a consortium or a centre[1], the following details must be provided:* – *the name of the consortium/centre;* – *the current members of the consortium/centre.*	**Heavy Ion Laboratory, Warsaw University,** **Pasteura 5A, 02-093 Warszawa** **Krzysztof Rusek**

1. Description of the underlying goals and objectives of the project, taking into account the project's contribution to expand and increase capability of the national scientific community as well as to improve competitiveness and increase the level of technological innovation of the Polish economy.
The description should include, in particular, the following aspects: – *the type (single-sited or distributed) and location of the proposed research infrastructure;* – *coherence of the project goals and objectives with the strategic framework set out in the government's strategic documents, including The Strategy for Responsible Development for the period up to 2020 (including the perspective up to 2030);* – *the expected project outcomes: scientific, economic, cultural and social (including whether the project successfully addresses the key societal challenges defined in the EU Framework Programme for Research and Innovation "Horizon 2020" [2]).*

[1] I.e. scientific consortium, industrial or scientific centre, centre of the Polish Academy of Sciences or academic scientific centre.
[2] "Horizon 2020" defines seven major societal challenges:
– health, demographic change and well-being,

SUMMARY

The heavy ion accelerator has been in use at the HIL UW for over 25 years. It is therefore projected to replace it with a new device that would demonstrate improved parameters of energy, ion range and beam intensity. This project will allow for a unique device to be present in Poland and in our part of Europe. It will be used to carry out fundamental research in the field of nuclear physics, including research into properties of superheavy elements as well as a variety of applications in nuclear power, medical science, research into the properties of solid targets, astrophysics and others. A vital part of this project is the possibility to ensure the highest level of training for students and scientists by means of access to one of the top devices of this kind in the world. This project constitutes part of the implementation of the high intensity stable beams (ECOS) programme, considered by the European Program FP7 EURONS and recommended by the Nuclear Physics European Collaboration Committee (NuPECC).

For several years now the European nuclear physics facilities have been examining the technical and financial possibilities to upgrade the existing and construct new cyclotrons accelerating high-intensity stable charged particles, from protons to uranium ions. This programme, called ECOS, is currently considered as a European 'distributed facility' having been analysed in detail within the European FP7 programme as one of the topics of the EURONS project. The Nuclear Physics European Collaboration Committee (NuPECC) warmly supported this project and contributed to the issue of a report devoted to this subject. One of the conclusions of this report reads as follows:

The recommendation of the committee is to ensure a strong support from both the nuclear physics community and the funding agencies for existing stable ion beam facilities not only for their accelerator system development but also for the instrumentation and experimental infrastructure that are needed to host dedicated research programmes.

The research infrastructure project presented below proposes placing a state-of-the-art heavy ion accelerator on the Polish Roadmap for Research Infrastructures, which would replace the existing accelerator that was set up in our facility over 25 years ago. The anticipated effect of this project will be an expansion and modernisation of the existing research infrastructure - the Heavy Ion Laboratory at the University of Warsaw (HIL UW). It would assume the role of a national laboratory equipped

- food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bioeconomy
- secure, clean and efficient energy,
- smart, green and integrated transport,
- climate action, environment, resource efficiency and raw materials,
- Europe in a changing world – inclusive, innovative and reflective societies,
- secure societies – protecting freedom and security of Europe and its citizens.

with the necessary apparatus that has been available to scientist from Poland and abroad for over twenty years Approximately one hundred scientists conduct research at our facility, half of them from abroad. The laboratory staff publish around 50 scientific papers per year in leading scientific publications. Approximately 20 theses per year (BSc, MSc, DSc, PhD) are based on the experiments performed at the laboratory. Polish students undertake internships as well as practical trainings within the workshops provided by the laboratory staff.

The apparatus available at HIL is developed on a regular basis. The construction of the central European Array for Gamma Levels Evaluation (EAGLE) spectrometer was completed in 2011. It remains the only device of this kind in Poland, living up to European standards. The European GAMMAPOOL consortium has recently equipped the spectrometer with detectors, the value of which amounts to several million PLN. In 2012, the opening of the Radiopharmaceuticals Production and Research Centre (RPRC) took place. The Centre comprises experimental and production areas and is one of the largest state-of-the-art facilities of this kind in Poland. The centre has enabled advances on radiopharmaceuticals applied to cancer diagnosis as well as contributing to the establishment of a collaboration with the radiopharmaceutical industry. Recently, an external target system for the PETtrace cyclotron at the RPRC has been constructed (patent No 227402 has been obtained for the design), which enabled the activities of this facility in the area of radiopharmaceutical research applied to cancer therapy to be expanded.

2014 marked the commissioning of the ECR ion source developed by Panotechnik: Supernanogun. This enabled a significant increase in the range of accelerated ions. It constitutes the only such source in the country. In 2017 it delivered the first metallic beam ^{24}Mg for the purpose of an experiment conducted at HIL. Work on replacing high-frequency generators that power the U-200P heavy ion cyclotron (a unique device in the country) will be concluded this year. A great number of new generators have been produced by a small, innovative Polish company called POPEK ELEKTRONIK in the city of Zamość, fulfilling one of the aspects of collaboration between science and industry.

The development of the laboratory has been widely recognized by the international community of nuclear physicists - HIL was included in the network of exclusive European facilities (the ENSAR2 consortium) and is among twelve top research infrastructures which receive European Union funding within the HORIZON2020 framework. The key experimental unit is the above mentioned U-200P cyclotron that accelerates ions ranging from helium to argon, to the energy of approx. 10 MeV/nucleon. It is the unique such cyclotron in Poland and Central Europe, delivering ion beams for 25 years. It was constructed in the seventies of the twentieth century. The core aim of this project is the purchase and installation of a new heavy ion accelerator to replace the existing U-200P. The new accelerator will allow the range of accelerated ions to be increased and provide the possibility to deliver ion beams of significantly higher intensity at HIL. The purchase of a next-generation cyclotron, similar to the DC-280 cyclotron installed at the Joint Institute for Nuclear Research in Dubna, seems a reasonable alternative. It will allow us to take advantage of the current infrastructure (the premises and apparatus) as well as the skills of the HIL employees. The replacement of the current U-200P cyclotron with a new model will allow the operational costs of the facility to be kept at the current level.

A harmonious development of fundamental research and its applications has a relevant importance for the development of the economy and the well-being of society. All major economic powers have a clear understanding of this situation - the USA funds and develops the Facility for Rare Isotope Beams (FRIB); FAIR - An International Facility for Antiproton and Ion Research is under construction in Germany and France is developing its SPIRAL2 project. Russia allocates significant funding to the development of the Joint Institute for Nuclear Research (JINR) in Dubna. The current project fits perfectly into this strategy, being closely related to the development of new specializations of the Polish economy, impacting the development of Polish companies, contributing to the worldwide expansion of Polish science and economy.

As noted above, HIL is a member of the European ENSAR2 consortium bringing together thirty European scientific units that received funding form the European Union within the HORIZON2020 network; the current project is a continuation of this programme with a particular focus on the following challenges:

- health, demographic change and well-being,
- secure, clean and efficient energy,
- secure societies – protecting freedom and security of Europe and its citizens.

2. Description of the unique nature of the project in terms of its national and international significance.

The description should include, in particular, the following aspects:

- *the planned use of the proposed research infrastructure in implementing breakthrough research and development programmes, including interdisciplinary ones, and the planned development of new technology, giving the reasons why these measures could not be implemented using the already existing research infrastructure;*
- *the national, regional, European or international availability of the proposed research infrastructure.*

The planned expansion will substantially enhance the development of scientific research performed not only at HIL but also in Poland and around the world.

Concerning matters relating to nuclear physics, research on superheavy nuclei is planned to be included in these fields of inquiry. Such research has up to now been conducted in only a couple of laboratories worldwide and joining them will significantly raise the prestige of domestic research. Research will be conducted within a broad international collaboration, however, the key partner will be the team of Professor Yuri Oganessian form the JINR in Dubna. His team has achieved spectacular results in this area (the chemical element Oganesson with the highest atomic number Z=118 and the highest mass was discovered in JINR). Polish physicists (prof. A.Sobiczewski, prof. J. Wilczyński, prof. K.Siwek-Wilczyńska and their respective students) have collaborated with Professor Oganessian for many years and have gained his full recognition, hence the immense support of Prof. Oganessian for this project. The fact that Poland is a member of the JINR makes the planned scientific collaboration significantly easier. The availability of high intensity heavy ions (e.g. ^{48}Ca) will allow the production of a vast amount of superheavy nuclei, the study of cross sections required for their synthesis, spectroscopic properties, decay of ground and isomeric states, Coulomb Excitations and transfer reactions. The study of their properties as well as the possibility to produce superheavy elements in astrophysical processes would constitute one area of expertise of our facility.

Intense beams of a wide range of heavy ions will also enable the expansion of current research on the structure of the nucleus to nuclei that are significantly further from the path of stability, both rich in neutrons (large N/Z) and rich in protons (low N/Z). This will allow, *inter alia*, an examination of the impact of the isospin quantum number T over a broad range of values, a search for exotic shapes of nuclei, an exploration of cluster and molecular states as well as research into the properties of nuclei that are far from the path of stability. One of the most up-to-date topics that might be pursued further is the investigation of fusion reaction mechanisms and the study of the near-and sub-barrier transfer reactions (research that HIL specializes in).

Apart from advancing research in the field of nuclear science, an increased range of available beams of greater intensity at HIL will allow the existing collaboration with domestic medical entities interested in cancer therapy via ion beams (hadron therapy) to be intensified. Research into the radiobiological effects caused by heavy ions (^{12}C, ^{16}O, ^{20}Ne) on *in vitro* cell material has been ongoing at HIL for the past ten years. In connection with a broader use of hadron therapy in cancer treatment there is a growing interest in such research among medical community. Together with the new accelerator, a new dedicated position with a vertical beam for such experiments will be installed. The results of the radiobiological research conducted at HIL are a vital factor contributing to an accurate planning of hadron therapy.

The possibility of works relating to the production of isotopes for medical purposes will increase, mainly with regard to diagnosis and cancer therapy applications. The therapeutic isotope ^{211}At is also worth mentioning. It is one of the most promising emitters of alpha particles in terms of therapeutic applications. The production of this isotope by means of the reaction (α,2n) or (^{6}Li,4n) with the use of high intensity ion beams will be quite effective. Another example of promising alpha particle emitter is the radioisotope ^{149}Tb, the production of which will be possible via the reaction ^{142}Nd(^{12}C,5n)^{149}Dy→^{149}Tb reaction without the complicated isotope separation of products of a spallation reaction. Both isotopes will be applied to the so-called alpha-immunotherapy - the destruction of cancerous cells by cutting the strands of their DNA helix. Moreover, the high intensities of the projected ion beams will extend the range of medical radioisotopes that can be produced.

The economic and scientific future of the world is closely connected with the exploration of space. The economic superpowers embrace and take advantage of this possibility. An increased interest in this topic can also be observed in Poland. The Polish Space Agency was established and small innovative undertakings are keen on constructing apparatus sent into space. HIL has established relations and initiated work related to research into the properties of high-temperature superconductors that are subjected to exposure to the stream of cosmic radiation. Beams of heavy ions perfectly simulate the radiation that is created as a result of the impact of high-energy protons of the cosmic radiation on the metal shell of a satellite. Electronic components sent into space must be tested in terms of their resistance to radiation damage. Greater beam intensity as well as an expansion of the range of energy and types of ions available will allow HIL to enter into cooperation with the Polish Space Agency as well as its scientific and industrial partners. In consequence, routine irradiation of equipment and components sent into space may prove possible in order to measure their radiosensitivity. This subject may be further pursued in collaborations with the defence industry - examining the resistance of the apparatus installed in fighter planes, helicopters and drones.

Poland is planning to create an international Centre of Excellence called NOMATEN, the aim of which is research into novel materials for industrial applications. This centre is being established in the National Centre of Nuclear Research in Świerk. (Shareholders: National Centre for Research and Development (NCBiR), Poland; Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA), France; Teknologian Tutkimuskeskus VTT Oy (VTT), Finland (EU grant H2020 under grant agreement No 763604). The availability of high-intensity heavy ion beams at HIL will enable a variety of studies on materials planned by NOMATEN (e.g. advanced nuclear power reactors, nuclear fusion). Another example worth introducing is the project of examining defects in graphene created by the use of various types of ions (research conducted by prof. Jagielski's team at NCNR).

In connection with the Polish nuclear power programme we my mention research into reactor materials and the change they undergo under the influence of bombardment with heavy ions, which in these experiments simulate products of fission in reactor rods. This research is currently conducted by the teams of prof. Jagielski and prof. Turos from the NCNR using heavy ion delivered accelerators from abroad. The new accelerator would enable such research to be carried out in Warsaw.

The availability of the new infrastructure will be on the basis of existing principles. HIL is a user laboratory that provides domestic and foreign users with access to its apparatus on principles equivalent to those of its European partner laboratories. The HIL Programme Advisory Committee consists of experts appointed by the Rector of the University of Warsaw for a period of four years. The Committee considers scientific research projects submitted by potential users and classifies them for implementation. Providing access to the apparatus on a commercial basis to economic institutions will take place via negotiations and binding agreements.

3. Description of the applicant's institutional and personnel capacity.

The description should include, in particular, the following aspects:

- *scientific category[3];*
- *the available research facilities and human resources which are relevant to project implementation, taking into account the planned measures to provide the staff who are able to operate and use the research infrastructure;*
- *experience in implementing national and international research infrastructure projects;*
- *experience in implementing national and international innovative research projects, as well as technology transfer projects over the last five years, including the list of major awarded grants (for a minimum of PLN 200 000 in the area of social sciences and humanities and a minimum of PLN 2 million in other areas of science) and the list of the major scientific publications (up to 30) and patents (up to 10 , including information regarding implementation, if possible) approved during the scientific categorisation process by the Minister of Science and Higher Education*

During the recent categorization performed by the Committee for the Evaluation of Scientific Units, HIL was awarded category B; an appeal against this decision was submitted to the court on June 1, 2018. This decision does not represent HIL's scientific position in an adequate manner since in the criterion No. 1 (scientific and creative accomplishments) the laboratory received a score that significantly exceeds the requirements for category A.

HIL is the only such facility in Poland, specializing in the acceleration of heavy ions. Its activity is presented during conferences devoted to acceleration issues and described in international publications (e.g. the NuPECC Long Range Plan 2017). HIL employs a team of dedicated staff with extensive

[3] If applicable. Where the application is submitted on behalf of a consortium or a centre, the scientific category of a scientific units representing the consortium / the centre and of all scientifically categorised consortium / centre members must be specified.

technical experience (approximately 30 technical employees, among them several with a doctoral degree). It also houses infrastructure, the ‘replacement value’ of which exceeds PLN 200 million. It consists of a main building comprising:

- Office space 2 000 m^2
- Experimental hall 800 m^2
- Measurement Room 160 m^2
- Conference room (for 120 participants) 150 m^2
- Lecture room 150 m^2
- Library 100 m^2
- Guest rooms for 10 visitors

and the Radiopharmaceuticals Research and Production Centre comprising, among others:

- Cyclotron block 47 m^2
- Production Laboratory I - 24 m^2
- Production Laboratory II – 23.4 m^2
- Personnel and material airlocks 34.7 m^2
- Quality control laboratory 33.8 m^2
- HVAC technical room 116.9 m^2
- Office space 50.9 m^2
- Archives 19.6 m^2

The radiopharmaceuticals production centre covers a total of 727 m^2. Permission to manufacture a medicinal product was issued for the first time on 07/07/2014. The facility meets the Good Manufacturing Practice standards.

HIL’s infrastructure is used to conduct research performed by international teams as well as entrepreneurs pursuing commercial activities. The administrative staff at HIL is trained in servicing these visitors and the guest rooms are ready for their arrival.

The planned construction of the new accelerator and its further maintenance will, however, require training of the technical staff as well as its rejuvenation. The planned construction work in cooperation with JINR Dubna will significantly facilitate this task, since we have maintained technical relations with this institute for many years. After the approval of this project and obtaining a declaration of appropriate funding we plan to employ two staff members chosen from the graduates of the Polish technical universities and offer them a one- or two-year internship at the Dubna facility in Russia. We have already been assured by JINR that this staffing solution is acceptable to them.

At the beginning of this century, HIL initiated and implemented a large investment project - the construction of the Radiopharmaceuticals Production and Research Centre. Within the framework of this project a new, high-current 16.5 MeV proton and 8.4 MeV deuteron commercial cyclotron was installed together with advanced radiochemical facilities. The implementation of this project was financed by the State Committee for Scientific Research, the International Atomic Energy Agency (IAEA) as well as European Funds (in total approximately PLN 25 million). During its first period of operation the Centre, together with a commercial company produced fluorodeoxyglucose, a radiopharmaceutical based on the radioactive fluorine isotope ^{18}F, used in positron emission tomography (PET) diagnoses. Currently, after equipping the cyclotron with an external irradiation line for solid targets (Patent No. 227402) by the technical team of HIL, research into other medical radioisotopes is being conducted (^{99m}Tc radioisotope as well as isotopes of Sc, among others). These studies were and still are supported by funds from two grants from the National Centre for Research and Development (agreement No. PBS1/A9/2/2012 and DZP/PBS3/2319/2014) as well as the International Atomic Energy Agency in Vienna in a project concluded in 2015 and coordinated by IAEA grant No. 17419 (2012-2015) “Accelerator-based alternatives to non-HEU production of Mo-99/Tc-99m” and the European grant ENSAR2.

HIL is experienced in implementing large scale domestic and international research programmes, taking part in the work of several consortia:

EAGLE – HIL is the coordinator of a collaboration between seven Polish and six European academic and scientific institutions conducting research into nuclear structure via gamma ray spectroscopy. The multi-detector gamma ray spectrometer EAGLE is used for this purpose, within the framework of the following projects:

- **POLONEZ 1:** Dr. Mansi Saxena
  Exploring the nuclear structure of nuclei in the vicinity of the Z = 50 closed shell using the Coulomb excitation technique
  2016-2018
  PLN 735 064
- **FUGA 5:** dr inż. Magdalena Matejska-Minda
  Determining the shape of nuclei by means of Coulomb excitation and measurement of femtosecond lifetimes of rotational bands formed in fusion-evaporation reactions

2014-2017

PLN 481 500

- **HARMONY 5** Dr. Julian Srebrny

  Experimental identification of exotic nuclear structures - using the EAGLE system with the cooperation of European nuclear physics facilities

  2014-2017

  PLN 1 941 000

There is active cooperation with the **European Gamma-Ray Spectroscopy pool** (GAMMAPOOL), which administers the highly efficient HpGe detectors from the EUROBALL system. As a result of a competition, HIL was granted the right to use these detectors in the years 2017-2019. In addition, the high standard of the germanium detector laboratory at HIL was one of the reasons HIL is considered as the so-called Home Base for these detectors until at least 2020.

ENSAR2 - a consortium of thirty European research institutions coordinated by GANIL (France) and associated in order to implement project 654002 — ENSAR2 within the HORIZON2020-Infrastructures programme. The aim of this project is to provide access to the European research infrastructure (including the U-200P) for joint research within the scope of low-energy nuclear physics.

- **HORIZON2020:** ENSAR2-European Research in Nuclear Physics and Applications there of 2

  2016-2020

  EUR 337 945.00

  Ministry of Science and Higher Education: Bonus on the horizon:

  PLN 288 131

COPIN - a consortium promoting a long-lasting collaboration with IN2P3 (France) within the framework of intergovernmental cooperation with France. The project is coordinated by the Institute of Nuclear Physics PAN. In 2016 HIL completed 4 research projects within the framework of this cooperation.

COPIGAL - a so-called associated European laboratory (LEA) created by the COPIN consortium (including HIL) as well as CNRS, GANIL and CEA (France), implementing the project NCN-Harmony4 *"The study of nuclei in unavailable areas of the chart of the nuclides by the application of radioactive beams and modern detection techniques"*, in which HIL participated in four tasks.

POLITA - an understanding between the COPIN and INFN consortia (Italy) implementing the NCN-Harmony6 programme *"Study of nuclei and nuclear processes in so far unavailable areas of spin, isospin and excitation energy with the use of modern detection and acceleration techniques."* HIL has taken part in three research tasks within this programme.

Poland@ISOLDE - a consortium of five Polish research institutions coordinated by the Faculty of Physics at Warsaw University, the aim of which is to conduct studies in the ISOLDE radioactive beam facility functioning within and on the territory of the European Organization for Nuclear Research (CERN) in Geneva, Switzerland. The consortium received funding towards access to the CERN-ISOLDE infrastructure within the framework of the NCN-HARMONY7 project *"Study of nuclides with the use of radioactive beams at the CERN-ISOLDE laboratory"*.

NLC (National Laboratory of Cyclotrons) - a consortium of HIL UW and INP PAS offering a unique scientific and research infrastructure in Poland. The joint facilities have proton and heavy ion beams at their disposal to conduct research in nuclear physics and nuclear medicine.

PET-SKAND – a consortium coordinated by the National Institute for Chemistry and Technology with the participation of HIL UW and BCNR-POLATOM for the realization of a joint project '*Preparation of radiopharmaceuticals labelled with scandium radionuclides for positron emission tomography',* funded by the National Centre for Research and Development as well as W15 of the European ENSAR2 project.

- **NCRD:** PET-SKAND
  Preparation of radiopharmaceuticals labelled with radionuclides for positron emission tomography
  2015-2018
  PLN 2 635 400

ALTECH - A consortium coordinated by BCNR-POLATOM with the participation of HIL UW and INCT for the realization of the joint project: *"Alternative methods of technetium-99m production"*

- **NCRD:** ALTECH
  Alternative methods of technetium-99m production
  2012-2016
  PLN 3 457 364

ERANET-NUPNET - within the framework of this European project the following research was conducted:

- **NCRD:** GANAS - Detection of gamma radiation with the use of modern scintillators (ERA-

NET NUPNET)
2012-2015
PLN 394 360

- **NCRD:** EMILIE - Increasing the charge state of short-lived isotopes for EURISOL (ERA-NET NUPNET)
  2012-2015
  PLN 698 017

CERAD- a project, fulfilled by a consortium, to make use of the new light particle accelerator for medical applications constructed at the NCNR in Świerk, Poland, within the framework of the EU Smart Growth programme 2014-2020; Priority IV: Increasing scientific and research potential. Work will be concluded in approximately 2021.

Investment projects:

2004

Decyzja: 4974/IA-IB/115/2004
IB-160/2004 „Adaptacja pomieszczeń dla cyklotronu i radiochemii Warszawskiego Ośrodka Tomografii Pozytonowej PET"
IA-2046/2004 „Wyposażenie Warszawskiego Ośrodka Tomografii Pozytonowej PET"
10 000 000 PLN

2005

Międzynarodowa Agencja Energii Atomowej
Projekt: POL/4/016
"Cyclotron Facility for Positron Emission Tomography Radiopharmaceutical Production"
2 515 024,12 PLN (800 000 USD)

2007

Ministerstwo Zdrowia
Umowa nr 4/7/2/2007/1834/3195 z 9.07.2007
Narodowy Program Zwalczania Chorób Nowotworowych
Tomografia Pozytonowa PET - budowa sieci ośrodków PET.
2 000 000 PLN

2008

Decyzja 5665/IA/115/2008
Źródło jonów ECR dla Warszawskiego cyklotronu U-200P.
2 550 000 PLN

WKP 1/1.4.3/2/2005/24/144/447/2007/U

Wyposażenie i modernizacja laboratorium innowacyjnych radiofarmaceutycków w Centrum Doskonałości PET.

3 558 409,11 PLN

2009

POIG.02.02.00-14-024/08-00

Centrum Badań Przeklinicznych i Technologii (CEPT)

Utworzenie pracowni chemii 11C i 15O CEPT

5 027 492,62 PLN

2010

Decyzja: 589/FNiTP/115/2010

Zakup, instalacja i uruchomienie dwóch generatorów wysokiej częstości dla Warszawskiego Cyklotronu U-200P

3 770 000 PLN

List of key publications:

1. S. Y. Mezhevych, A. T. Rudchik, A. A. Rudchik, O. A. Ponkratenko, N. Keeley, K. W. Kemper, M. Mazzocco, K. Rusek and S. B. Sakuta; ***Cluster structure of 17O***, Phys. Rev. C **95** (2017) 034607.
2. J. Perkowski, J. Andrzejewski, C. Droste, L. Janiak, E. Grodner, S. G. Rohozinski, L. Próchniak, J. Srebrny, J. Samorajczyk-Pyśk, T. Abraham, K. Hadyńska-Klęk, M. Kisieliński, M. Komorowska, M. Kowalczyk, J. Kownacki, T. Marchlewski, J. Mierzejewski, P. Napiorkowski, A. Stolarz, A. Korman and M. Zielińska; ***Decay of the Ip=8- isomeric state in 134Nd and 184Pt studied by electron and gamma spectroscopy***, Phys. Rev. C **95** (2017) 014305.
3. K. Szkliniarz, M. Sitarz, J. Jastrzębski, J. Choiński, A. Jakubowski, K. Kapinos, M. Kisieliński, A. Stolarz, A. Trzcińska, J. Wojtkowska and W. Zipper; ***Production efficiency and radioisotopic purity of 99mTc formed using the (p,2n) reaction on a highly enriched 100Mo target***, Mod. Phys. Lett. A **32** (2017) 1740012.
4. D. T. Doherty, J. M. Allmond, R. V. F. Janssens, W. Korten, S. Zhu, M. Zielińska, D. C. Radford, A. D. Ayangeakaa, B. Bucher, J. C. Batchelder, C. W. Beausang, C. Campbell, M. P. Carpenter, D. Cline, H. L. Crawford, H. M. David, J. P. Delaroche, C. Dickerson, P. Fallon, A. Galindo-Uribarri, F. G. Kondev, J. L. Harker, A. B. Hayes, M. Hendricks, P. Humby, M. Girod, C. J. Gross, M. Klintefjord, K. Kolos, G. J. Lane, T. Lauritsen, J. Libert, A. O. Macchiavelli, P.

J. Napiorkowski, E. Padilla-Rodal, R. C. Pardo, W. Reviol, D. G. Sarantites, G. Savard, D. Seweryniak, J. Srebrny, R. Varner, R. Vondrasek, A. Wiens, E. Wilson, J. L. Wood and C. Y. Wu; ***Triaxiality near the 110Ru ground state from Coulomb excitation***, Phys. Lett. B **766** (2017) 334.

5. J.Choiński, J.Jastrzębski, P.J. Napiorkowski, M.Sitarz, A.Stolarz, K.Szkliniarz, A.Trzcińska, J.Wojtkowska, W.Zipper, **Medical Radioisotopes Produced with Cyclotron Beams in Warsaw**, *Ann. Rad. Therapy and Oncology, (2017),1, 1005.*
6. K. Kilian, K. Pyrzyńska and M. Pęgier; ***Comparative Study of Sc(III) Sorption onto Carbon-based Materials***, Solvent Extr. Ion Exch. **35** (2017) 450-459.
7. A. T. Rudchik, A. A. Rudchik, L. M. Muravynets, K. W. Kemper, K. Rusek, E. Piasecki, A. Trzcińska, E. I. Koshchy, V. M. Pirnak, O. A. Ponkratenko, I. Strojek, A. Stolarz, O. V. Herashchenko, Y. M. Stepanenko, V. A. Plujko, S. B. Sakuta, R. Siudak and A. Szczurek; ***Elastic and inelastic scattering of 15N ions by 7Li at 81 MeV versus that of 14N ions by 7Li at 80 and 110 MeV***, Nucl. Phys. A **958** (2017) 234.
8. A. Sentkowska, K. Kilian, M. Kopeć, K. Pyrzyńska and L. Cheda; ***Ga(III) complex with morin for kidney cancer cell labelling***, Appl. Organomet. Chem. **31** (2017) e3882.
9. E. Clement, M. Zielinska, A. Gorgen, W. Korten, S. Peru, J. Libert, H. Goutte, S. Hilaire, B. Bastin, C. Bauer, A. Blazhev, N. Bree, B. Bruyneel, P. A. Butler, J. Butterworth, P. Delahaye, A. Dijon, D. T. Doherty, A. Ekstrom, C. Fitzpatrick, C. Fransen, G. Georgiev, R. Gernhauser, H. Hess, J. Iwanicki, D. G. Jenkins, A. C. Larsen, J. Ljungvall, R. Lutter, P. Marley, K. Moschner, P. J. Napiorkowski, J. Pakarinen, A. Petts, P. Reiter, T. Renstrom, M. Seidlitz, B. Siebeck, S. Siem, C. Sotty, J. Srebrny, I. Stefanescu, G. M. Tveten, J. V. de Walle, M. Vermeulen, D. Voulot, N. Warr, F. Wenander, A. Wiens, H. D. Witte and K. Wrzosek-Lipska; ***Spectroscopic Quadrupole Moments in 96,98Sr: Evidence for Shape Coexistence in Neutron-Rich Strontium Isotopes at N=60***, Phys. Rev. Lett. **116** (2016) 022701.
10. K. Hadynska-Klek, P. J. Napiorkowski, M. Zielinska, J. Srebrny, A. Maj, F. Azaiez, J. J. V. Dobon, M. Kicinska-Habior, F. Nowacki, H. Naidja, B. Bounthong, T. R. Rodriguez, G. de Angelis, T. Abraham, G. A. Kumar, D. Bazzacco, M. Bellato, D. Bortolato, P. Bednarczyk, G. Benzoni, L. Berti, B. Birkenbach, B. Bruyneel, S. Brambilla, F. Camera, J. Chavas, B. Cederwall, L. Charles, M. Ciemala, P. Cocconi, P. Coleman-Smith, A. Colombo, A. Corsi, F. C. L. Crespi, D. M. Cullen, A. Czermak, P. Desesquelles, D. T. Doherty, B. Dulny, J. Eberth, E. Farnea, B. Fornal, S. Franchoo, A. Gadea, A. Giaz, A. Gottardo, X. Grave, J. Grebosz, A. Gorgen, M. Gulmini, T. Habermann, H. Hess, R. Isocrate, J. Iwanicki, G. Jaworski, D. S. Judson, A. Jungclaus, N. Karkour, M. Kmiecik, D. Karpinski, M. Kisielinski, N. Kondratyev,

A. Korichi, M. Komorowska, M. Kowalczyk, W. Korten, M. Krzysiek, G. Lehaut, S. Leoni, J. Ljungvall, A. Lopez-Martens, S. Lunardi, G. Maron, K. Mazurek, R. Menegazzo, D. Mengoni, E. Merchan, W. Meczynski, C. Michelagnoli, J. Mierzejewski, B. Million, S. Myalski, D. R. Napoli, R. Nicolini, M. Niikura, A. Obertelli, S. F. Ozmen, M. Palacz, L. Prochniak, A. Pullia, B. Quintana, G. Rampazzo, F. Recchia, N. Redon, P. Reiter, D. Rosso, K. Rusek, E. Sahin, M.-D. Salsac, P.-A. Soderstrom, I. Stefan, O. Stezowski, J. Styczen, C. Theisen, N. Toniolo, C. A. Ur, V. Vandone, R. Wadsworth, B. Wasilewska, A. Wiens, J. L. Wood, K. Wrzosek-Lipska and M. Zieblinski; ***Superdeformed and Triaxial States in 42Ca***, Phys. Rev. Lett. **117** (2016) 062501.

11. K. Kilian, M. Pegier, A. Pekal and K. Pyrzynska; ***Distribution and separation of metallic and radionuclidic impurities in the production of F-18-fluorodeoxyglucose***, J. Radioanal. Nucl. Chem. **307** (2016) 1037-1043.
12. K. Kilian, M. Pegier and K. Pyrzyńska; ***The fast method of Cu-porphyrin complex synthesis for potential use in positron emission tomography imaging***, Spectrochim. Acta A-Molecular and Biomolecular Spectr. **159** (2016) 123-127.
13. M. Klintefjord, K. Hadynska-Klek, A. Gorgen, C. Bauer, F. L. B. Garrote, S. Bonig, B. Bounthong, A. Damyanova, J.-P. Delaroche, V. Fedosseev, D. A. Fink, F. Giacoppo, M. Girod, P. Hoff, N. Imai, W. Korten, A.-C. Larsen, J. Libert, R. Lutter, B. A. Marsh, P. L. Molkanov, H. Naidja, P. Napiorkowski, F. Nowacki, J. Pakarinen, E. Rapisarda, P. Reiter, T. Renstrom, S. Rothe, M. D. Seliverstov, B. Siebeck, S. Siem, J. Srebrny, T. Stora, P. Thole, T. G. Tornyi, G. M. Tveten, P. V. Duppen, M. J. Vermeulen, D. Voulot, N. Warr, F. Wenander, H. D. Witte and M. Zielinska; ***Structure of low-lying states in 140Sm studied by Coulomb excitation***, Phys. Rev. C **93** (2016) 054303.
14. A. T. Rudchik, K. A. Chercas, K. W. Kemper, K. Rusek, A. A. Rudchik, O. V. Herashchenko, E. I. Koshchy, V. M. Pirnak, E. Piasecki, A. Trzcinska, S. B. Sakuta, R. Siudak, I. Strojek, A. Stolarz, A. P. Ilyin, O. A. Ponkratenko, Y. M. Stepanenko, Y. O. Shyrma, A. Szczurek and V. V. Uleshchenko; ***Elastic and inelastic scattering of 15N ions by 9Be at 84 MeV***, Nucl. Phys. A **947** (2016) 161.
15. K. Szkliniarz, M. Sitarz, R. Walczak, J. Jastrzebski, A. Bilewicz, J. Choinski, A. Jakubowski, A. Majkowska, A. Stolarz, A. Trzcinska and W. Zipper; ***Production of medical Sc radioisotopes with an alpha particle beam*** , Appl. Radiat. Isot. **118** (2016) 182--189.
16. A. Trzcinska, E. Piasecki, A. Amar, W. Czarnacki, N. Keeley, M. Kisielinski, S. Kliczewski, M. Kowalczyk, B. Lommel, M. Mutterer, R. Siudak, A. Stolarz, I. Strojek, G. Tiourin and W. H. Trzaska; ***Examination of the influence of transfer channels on the barrier height***

distribution: Scattering of 20Ne on 58Ni, 60Ni, and 61Ni at near-barrier energies, Phys. Rev. C **93** (2016) 054604.

17. F. L. B. Garrote, A. Gorgen, J. Mierzejewski, C. Mihai, J. P. Delaroche, M. Girod, J. Libert, E. Sahin, J. Srebrny, T. Abraham, T. K. Eriksen, F. Giacoppo, T. W. Hagen, M. Kisieliński, M. Klintefjord, M. Komorowska, M. Kowalczyk, A. C. Larsen, T. Marchlewski, I. O. Mitu, S. Pascu, S. Siem, A. Stolarz and T. G. Tornyi; ***Lifetime measurement for the 2+ state in 140Sm and the onset of collectivity in neutron-deficient Sm isotopes***, Phys. Rev. C **92** (2015) 024317.
18. U. Kaźmierczak, D. Banaś, J. Braziewicz, J. Czub, M. Jaskóła, A. Korman, M. Kruszewski, A. Lankoff, H. Lisowska, A. Malinowska, T. St¸ epkowski, Z. Szefliński and M. Wojewódzka; ***Dosimetry in radiobiological studies with the heavy ion beam of the Warsaw cyclotron***, Nucl. Instrum. Methods Phys. Res. B **365** (2015) 404-408.
19. N. Keeley, K. W. Kemper and K. Rusek; ***Strong multistep interference effects in 12C(d, p) to the 9/2+ state in 13C***, Phys. Rev. C **92** (2015) 054618.
20. A. J. Kordyasz, N. L. Neindre, M. Parlog, G. Casini, R. Bougault, G. Poggi, A. Bednarek, M. Kowalczyk, O. Lopez, Y. Merrer, E. Vient, J. D. Frankland, E. Bonnet, A. Chbihi, D. Gruyer, B. Borderie, G. Ademard, P. Edelbruck, M. F. Rivet, F. Salomon, M. Bini, S. Valdre, E. Scarlini, G. Pasquali, G. Pastore, S. Piantelli, A. Stefanini, A. Olmi, S. Barlini, A. Boiano, E. Rosato, A. Meoli, A. Ordine, G. Spadaccini, G. Tortone, M. Vigilante, E. Vanzanella, M. Bruno, S. Serra, L. Morelli, M. Guerzoni, R. Alba, D. Santonocito, C. Maiolino, M. Cinausero, F. Gramegna, T. Marchi, T. Kozik, P. Kulig, T. Twarog, Z. Sosin, K. Gasior, A. Grzeszczuk, W. Zipper, J. Sarnecki, D. Lipinski, H. Wodzinska, A. Brzozowski, M. Teodorczyk, M. Gajewski, A. Zaqojski, K. Krzyzak, K. J. Tarasiuk, Z. Khabanowa and L. Kordyasz; ***Low-temperature technique of thin silicon ion implanted epitaxial detectors***, Eur. Phys. J. A **51** (2015) 15.
21. A. T. Rudchik, O. V. Herashchenko, K. W. Kemper, K. Rusek, S. Kliczewski, K. A. Chercas, A. A. Rudchik, E. I. Koshchy, V. M. Pirnak, E. Piasecki, A. Trczinska, S. B. Sakuta, R. Siudak, I. Strojek, A. Stolarz, A. O. Barabash, A. P. Ilyin, O. A. Ponkratenko, Y. M. Stepanenko, Y. O. Shyrma, V. V. Uleshchenko, J. Choiński and A. Szczurek; ***15N elastic and inelastic scattering by 11B at 84 MeV***, Nucl. Phys. A **939** (2015) 1.
22. A. T. Rudchik, O. V. Herashchenko, K. W. Kemper, K. Rusek, S. Kliczewski, K. A. Chercas, A. A. Rudchik, E. I. Koshchy, V. M. Pirnak, E. Piasecki, A. Trzcińska, S. B. Sakuta, R. Siudak, I. Strojek, A. Stolarz, S. O. Odzhikovskyi, A. P. Ilyin, O. A. Ponkratenko, Y. M. Stepanenko, Y. O. Shyrma, V. V. Uleshchenko and A. Szczurek; ***Elastic and inelastic scattering of 14N ions by 11B at 88 MeV versus that of 15N + 11B at 84 MeV***, Nucl. Phys. A **941** (2015) 167.

23. K. Rusek, N. Keeley, K. W. Kemper and A. T. Rudchik; ***Effect of the exit reaction channels on 6Li+18O elastic scattering***, Phys. Rev. C **91** (2015) 044612.
24. J. Samorajczyk, M. Klintefjord, C. Droste, A. Gorgen, T. Marchlewski, J. Srebrny, T. Abraham, F. L. B. Garrote, E. Grodner, K. Hadyńska-Klęk, M. Kisieliński, M. Komorowska, M. Kowalczyk, J. Kownacki, P. Napiorkowski, R. Szenborn, A. Stolarz, A. Tucholski and G. M. Tveten; ***Revised spin values of the 991 keV and 1599 keV levels in 140Sm***, Phys. Rev. C **92** (2015) 044322.
25. A. Stolarz, J. A. Kowalska, P. Jasinski, T. Janiak and J. Samorajczyk; ***Molybdenum targets produced by mechanical reshaping***, J. Radioanal. Nucl. Chem. **305** (2015) 947-952.
26. A. Trzcińska, E. Piasecki, K. Hagino, W. Czarnacki, P. Decowski, N. Keeley, M. Kisieliński, P. Koczon, A. Kordyasz, E. Koshchiy, M. Kowalczyk, B. Lommel, A. Stolarz, I. Strojek and K. Zerva; ***Quasielastic barrier distributions for the 20Ne + 58,60,61Ni systems: Influence of weak channels***, Phys. Rev. C **92** (2015) 034619
27. J. Perkowski, J. Andrzejewski, Ł. Janiak, J. Samorajczyk, T. Abraham, Ch. Droste, E. Grodner, K. Hadyńska- Klęk, M. Kisieliński, M. Komorowska, M. Kowalczyk, J. Kownacki, J. Mierzejewski, P. Napiorkowski, A. Korman, J. Srebrny, A. Stolarz, and M. Zielińska, **University of Lodz an electron spectrometer—A new conversion-electron spectrometer for "in-beam" measurements,** Review of Scientific Instruments 85 (2014) , 043303
28. L. P. Gaffney, P. A. Butler1, M. Scheck, A. B. Hayes, F. Wenander, M. Albers5, B. Bastin, C. Bauer, A. Blazhev, S. Bonig, N. Bree, J. Cederkall, T. Chupp, D. Cline, T. E. Cocolios, T. Davinson, H. De Witte, J. Diriken, T. Grahn, A. Herzan, M. Huyse, D. G. Jenkins, D. T. Joss1, N. Kesteloot, J. Konki, M. Kowalczyk, Th. Kroll, E. Kwan, R. Lutter, K. Moschner, P. Napiorkowski, J. Pakarinen, M. Pfeiffer, D. Radeck, P. Reiter, K. Reynders, S. V. Rigby1, L. M. Robledo, M. Rudigier, S. Sambi, M. Seidlitz, B. Siebeck, T. Stora, P. Thoele, P. Van Duppen, M. J. Vermeulen, M. von Schmid, D. Voulot, N. Warr, K. Wimmer, K. Wrzosek-Lipska, C. Y. Wu and M. Zielinska, **Studies of pear-shaped nuclei using accelerated radioactive beams,** *Nature* **497** (2013), 199
29. B. Cederwall, F. Ghazi Moradi, T. B¨ack, A. Johnson, J. Blomqvist, E. Cle´ment, G. de France, R. Wadsworth, K. Andgren, K. Lagergren, A. Dijon, G. Jaworski, R. Liotta, C. Qi, B. M. Nyako, J. Nyberg, M. Palacz, H. Al-Azri, A. Algora, G. de Angelis, A. Ataç, S. Bhattacharyya, T. Brock, J. R. Brown, P. Davies, A. Di Nitto, Zs. Dombradi, A. Gadea, J. Ga, B. Hadinia, F. Johnston-Theasby, P. Joshi, K. Juhasz, R. Julin, A. Jungclaus, G. Kalinka, S. O. Kara, A. Khaplanov, J. Kownacki, G. La Rana, S. M. Lenzi, J. Molnar, R. Moro, D. R. Napoli, B. S. Nara Singh, A. Persson, F. Recchia, M. Sandzelius, J.-N. Scheurer, G. Sletten, D. Sohler,

P.-A. Soderstrom, M. J. Taylor, J. Timar, J. J. Valiente-Dobon, E. Vardaci and S. Williams; **Evidence for a spin-aligned neutron–proton paired phase from the level structure of 92Pd,** NATURE 469 (2011), 68

30. J.Mierzejewski, J.Srebrny, H.Mierzejewski, J.Andrzejewski, W.Czarnacki, Ch.Droste, E.Grodner, A.Jakubowski, M.Kisieliński, M.Komorowska, A.Kordyasz, M.Kowalczyk, J.Kownacki, A.A.Pasternak, J.Perkowski, A.Stolarza, M.Zielińska, R.Anczkiewicz, **EAGLE—the central European Array for Gamma Levels Evaluation at the Heavy Ion Laboratory of the University of Warsaw**, Nuclear Instruments and Methods in Physics 659 (2011), 84

Patent:

The Patent Office has issued a patent No 227402 to the Warsaw University for the invention "System of external target position'. The authors of this invention are employees of HIL.

4. Description of the level of interest in the project shown by the scientific and research community and the relevant businesses at national and international level, in particular during the operational phase of the proposed research infrastructure.

The description should include, in particular, the following aspects:

- *entities interested in project implementation;*
- *a set of rules concerning the access of external users, including foreign ones, to carry out scientific research and development works using the proposed research infrastructure;*
- *the plans to establish and extend the base of prospective users;*
- *the planned contribution of external experts, including foreign ones, to the development of the scientific goals and growth strategies for research infrastructure.*

The community of European scientists has recognized, over the last several years, the need to build a laboratory that will have at its disposal a wide range of beams of stable heavy ions. In the eighties of the twentieth century interest in radioactive beams was fuelled and resulted in the creation of laboratories with such beams at their disposal, to the detriment of the availability of stable beams. The European ECOS project, initiated by NuPECC, intended to construct such a centre from scratch. One of the initial ideas for its location was at the LINCE laboratory in Spain. However, this implementation failed due to the financial crisis in this country. In this way an opportunity arose to develop the ideas of ECOS in Poland. The entire community of European nuclear physicists, coordinated by NuPECC, demonstrates a keen interest in this project. Selected matters relating to the ECOS concept are currently implemented within the TecHIBA task, constituting part of the ENSAR2 programme.

This project in consistent with ECOS and is therefore supported by NuPECC. It is also supported by JINR in Dubna as well as the Nuclear Physics Section of the Polish Physical Society. The project is supported by the following Polish scientific organisations:

- Department of Physics, University of Warsaw(UW), Warsaw
- M. Smoluchowski Institute of Physics, Jagiellonian University (UJ), Cracow
- Institute of Physics, Silesian University, Katowice
- Faculty of Physics and Applied Computer Science, University of Łódź, Łódź
- Department of Mathematics, Physics and Computer Science, The Maria Curie-Skłodowska University (UMCS), Lublin
- National Centre for Nuclear Research, Świerk
- Institute of Nuclear Physics, Polish Academy of Sciences, Cracow.

The principles for gaining access to the HIL@ECOS laboratory will be similar to those currently in place. It will continue to be a laboratory providing domestic and foreign users with access to its apparatus on principles equivalent to those at similar European laboratories. Beam time will be allocated by the Director based on the recommendations of an international Programme Advisory Committee, consisting of experts appointed by the Rector of the University of Warsaw for a period of four years. The Committee will consider scientific research projects submitted by potential users and classify them for implementation. Providing access to the apparatus on a commercial basis to economic institutions will take place via negotiations and binding agreements.

The already extensive HIL user base will significantly expand due to the improved ability to deliver ion beams. HIL@ECOS will be included in the network of European laboratories of this kind, therefore it will also be able to take advantage of the user bases of these laboratories. Foreign experts will thus be involved in the process of formulating the scientific and development strategies of the facility.

5. Estimated project implementation costs, including those that are to be incurred during the operational phase of the proposed research infrastructure, as well as information regarding the proposed funding sources.

The description should include, in particular, the following aspects:

- *description of the costs involved as broken down into investment-related costs and those related to the use of the research infrastructure, on an annual basis and viewed as a whole;*
- *planned measures to cover these costs within the period of 3 to 5 years, including: applicant's own resources, funding from the national budget (including structural funds allocated under operational programmes), funds from the European Union budget, other public funds, private contributions;*
- *the planned commercial use of the proposed research infrastructure, including for economic purposes, taking into account the rules on state aid.*

The expected costs of project implementation amount to PLN 85 million. These are the costs connected with the purchase and installation of the accelerator (heavy ion cyclotron). The operating costs of the modernised centre should be in line with current expenditure, i.e. approximately PLN 10 million/year (including remuneration). These costs could even be reduced since the operation of the new cyclotron will be more economical in terms of water and energy consumption. Funding will be distributed over a period of several years from a variety of sources.

The major cost – the purchase and setting up of the new accelerator - may be financed within an investment decision or within a collaboration programme between Poland and JINR Dubna. We are also counting on future scientific funding programmes from the EU. The construction and development of experimental stations will take place on the basis of research grants, investment projects and within the framework of scientific collaborations with other scientific facilities (loan of detectors and measurement installations as in the case of the ICARE and EAGLE systems) as well as cooperation with industrial partners.

It is envisaged that ion beams for business entities will be delivered on a commercial basis. Assuming that such entities will take advantage of 30 per cent of the beam time (2000 hours per year), this could contribute around PLN 4 million to the budget of the laboratory. A related point to consider is that the infrastructure of the modernised laboratory will also be attractive to companies from abroad and international agencies, e.g. the European Space Agency (ESA).

6. Description of the scientific and technical concept underlying the project implementation.

The description should include, in particular, the following aspects:

- *the scientific, technical and organisational challenges likely to be faced during the construction and operation of the proposed research infrastructure;*
- *major risks and ways to reduce them;*
- *implementation schedule for project tasks, including a description of major project stages and milestones;*
- *the possibility of using the already existing research facilities and buildings in project implementation.*

The anticipated technical and scientific challenges:

1. designing a dedicated cyclotron for HIL on the basis of acquired knowledge and experience, that would accelerate ions in the range of He to U with energies of approx. 10 MeV/u and currents of 10 pμA so that the accelerator would fit into the present bunker;
2. conducting magnetic field modelling;
3. rebuilding of the injection line taking into consideration the ECR ion source housed by HIL.
4. rebuilding of the magnetic canal used to exit ion beams from the cyclotron.

5. reconstruction of the resonators from vertical into horizontal ones due to lack of space in the present bunker.

The anticipated organisational challenges during the construction process:

1. Obtaining a potential buyer for the disassembled U-200P cyclotron.
2. Organizing transportation of the cyclotron from the present bunker and a necessity, resulting from that fact, to disassemble ion tubes and experimental positions, as the only escape route leads through the experiment hall.
3. A necessity to store disassembled ion tubes and experimental positions for the period during which the new cyclotron is built.
4. Coordination of adaptation and construction works with the technical requirements of the new cyclotron so that after the delivery of the cyclotron to Warsaw there are no issues with the connection of the cyclotron to utility networks and the remaining infrastructure;

The anticipated challenges of using the planned research infrastructure:

1. Gaining mastery in using the new equipment of the cyclotron together with the modified or reinstalled utilities.
2. Optimising the parameters of the cyclotron operation for various heavy ion beams;
3. Optimising the parameters of ion source of the ECR type as well as the injection line for various beams of heavy ions so that a maximum transmission of ion insertion into the centre of the cyclotron is obtained.
4. Optimising the parameters of ion optics installed on the ion tubes for various beams of heavy ions:
5. Definition of access zones to the research infrastructure taking into consideration a substantial increase in the hazards caused by strong-current ion energy beams.

The key risks and means of minimizing thereof:

1. The project funding lasts usually three years - it is necessary to prolong this time. Funding might be distributed over a period of time and connected with the achieved stages, however, it has to be ensured for the whole period of 5-8 years.
2. There is no cyclotron on the market that would be suitable to execute the implementation of assumed research programmes - therefore talks with potential contractors are necessary as soon as the project is included in the ‘roadmap’ with the aim to conduct initial construction works and valuation of potential alternative solutions.
3. A lack of adequate concrete floor strength in the cyclotron room - conducting the necessary construction works.

4. The path along which the cyclotron is going to be transported does not have a sufficient load-bearing capacity - immediately after obtaining information on the heaviest element of the cyclotron an expertise needs to be commissioned in order to find out what needs to be done and where to facilitate the transport of the cyclotron.
5. Issue with obtaining permits for the operation of the cyclotron - collaboration with the PAA needs to be established at the initial stage of the construction of the cyclotron in order to receive up-to-date guidelines regarding safety conditions for the operational staff and the environment.

Timeline

The most important stages of this undertaking together with the milestones

1. Entering the 'roadmap" - starting point of project implementation
2. Talks with potential contractors of the cyclotron - during the first year
   - collecting data on technical parameters of potential cyclotrons that ensure the realization of the research programme foreseen to be implemented via the new cyclotron;
   - return to negotiations with potential manufacturers with the aim to lay down requirements for cyclotrons that would allow for their insertion into the existing premises after performing all necessary adaptations thereto;
   - estimation of construction costs of the cyclotron together with adaptations for each version;
3. Receiving funds to finance the total investment - a time frame of two years to find sources of funding (the end of the second year of project implementation)
4. Preparing tender documentation for the cyclotron - the first half of the third year of project implementation
5. Launching a call for tenders for the cyclotron - second half of the third year of project implementation
6. Announcing the winner of the tender for the cyclotron - second half of the third year of project implementation
7. Contract execution for the cyclotron
   - preparing technical documentation of the cyclotron;
   - approving the documentation by the investor;
   - construction of components of the cyclotron;
   - transport and assembly of the cyclotron at the HIL premises;
   - tests of cyclotron parameters including SAT.
8. Drafting technical requirements for the adjustments and rebuilding of existing premises in cooperation with the winner of the cyclotron tender – second/third quarter of the fourth year

9. Launching a call for tenders for a contractor to perform adjustments and rebuilding works - first half of the fourth year of product implementation.
10. Announcing the winner of the tender for the adjustment and rebuilding of premises - the first half of the fourth year of project implementation
11. Contract execution for the adjustment and rebuilding of premises - second half of the fourth year of project implementation, execution duration three years and three quarters
    - drafting of documentation for the purpose of obtaining building permits with the consultation of the investor and the cyclotron contractor;
    - obtaining permits for the construction;
    - creating documentation of implementation;
    - purchase of necessary materials and equipment to adapt or build new installations necessary for the operation of the cyclotron;
    - execution of adjustments and rebuilding works in accordance with the investor-approved executive documentation;
    - approval of construction works by the investor with the participation of the contractor of the cyclotron; concluding this adjustment and rebuilding stage falls on the first quarter of the eighth year of project implementation;
12. Coordination of cooperation between the cyclotron contractor and the contractor responsible for rebuilding and adjustment works - second half of the fourth year of project implementation, execution duration three years and three quarters
13. Disassembly of the U-200P cyclotron - during the fourth quarter of the third year of project implementation
    - search for a facility that would be willing to purchase the U-200P cyclotron;
    - obtaining permits from the PAA regarding the disassembly and utilisation of the cyclotron;
    - preparing tender documentation in case the number of parties interested is larger than anticipated;
    - announcement of the call for tenders;
    - selecting the winner;
    - disassembly and utilisation of the cyclotron – second half of the fourth year of project implementation;

or in the case of a lack of any purchasing parties

- obtaining permits from the PAA regarding the disassembly and utilisation of the cyclotron;
- preparing tender documentation for the disassembly of the cyclotron;
- announcement of the call for tenders;

- selection of a company that will disassemble the cyclotron;
- disassembly and utilisation of the cyclotron - first quarter of the fifth year of project implementation.

14. Setting up the new cyclotron for operation - second half of the eighth year of project implementation

The existing research apparatus in the form of large elements of the infrastructure:
EAGLE is a multidetector system used to measure discrete gamma spectra. The laboratory is housing 23 HPGe detectors and 15 anti-Compton shields made of BGO crystals which can be installed on the EAGLE frame. In 2015 the laboratory received a loan of several highly efficient HPGe detectors from the European Gamma-Ray Spectroscopy Pool. Those detectors are the property of institutes from France, Germany, Italy and Great Britain and will be used on the beam form the U-200P cyclotron with the aim to realize the programme of joint measurements. The mechanics of the system allows to install up to 30 germanium detectors in Compton suppression shields as well as numerous auxiliary detectors.

- a multiplicity filter consisting of 60 BaF2 detectors covering the angle of 4π;
- a 30-element silicon detector for the detection of charged particles;
- the so-called ‘Munich Chamber’ - a system of PIN-diode semiconductor detectors used to detect heavy ions (the construction of the chamber allows to install up to 110 detectors);
- an electron spectrometer
- a foursectored HPGe polarimeter;
- a plunger.

Research topics pursued with the use of the EAGLE system and the above-mentioned auxiliary detectors:

- study of atom nuclei structure
- measurements of high spin states;
- search for isomers
- measurements of lifetimes of nuclei states,
- Coulomb excitation research (study of nuclei shapes)

ICARE – is a charged particle detector system used for their identification and energy measurements, built in the IReS (Strasbourg), it is presently installed at HIL at the measurement line D. The ICARE unit consists of a 1m diameter reaction chamber with up to 48 ‘E-ΔE’ gas, semiconductor and scintillator telescopes. The construction of the chamber allows for the detectors to be mounted in any configuration preferred by users, using internal mounts. It can be remotely operated without the necessity of opening the reaction chamber. In the future, the unit will be rebuilt to include a system to measure the time of flight (ToF).

Conducted and suggested research topics with the use of the ICARE system: experiments requiring great precision in the identification and measurement of the energy of charged particles: researching the properties of isotopes far-from-stability produced in heavy ion reactions, research on fusion barrier distribution with quasi - elastic scattering methods, research of nuclei deformation by means of an analysis of spectra emitted by light charged particles, research on nuclear reaction mechanisms.

SYSTEM FOR RADIOBIOLOGICAL EXPERIMENTS, installed at the measurement line A.
It is where research regarding radiobiological effects takes place after the irradiation of cells with heavy ions as well as experiments pertaining to nanodosimetry.

MATERIAL IRRADIATION POSITIONS - There exist three irradiation positions in the laboratory:

- the position for direct irradiation with ion sources of the ECR type,
- the irradiation chamber at the first section of the ion tube
- the position for irradiation with an internal beam.

Research topics: study of physicochemical alteration of materials as a result of irradiation with charged high energy particles; production of ^{211}At for research on ways to produce ^{211}At-labelled radiopharmaceuticals.

LOW-BACKGROUND LABORATORY - the laboratory houses 5 HPGe (of coaxial, loax and plannar type) detectors at its disposal and 3 lead shields the wall thickness of which is 10 cm, made from selected lead with low levels of natural radioactivity.
Research matters: the study of irradiated samples in accelerators, the study of environmental and biological samples.
Irradiated samples with ^{211}At are also examined in the low-background laboratory before being further processed at the Institute of Nuclear Chemistry and Technology. The aim of those measurements is the estimation of efficiency of ^{211}At production. Measurements of isotope purity of ^{225}Ac production are also planned.
Obviously at this moment it is difficult to estimate what the state of research equipment and working teams is going to be like in 7-8 years. Without a shred of doubt the gathered apparatus, of great material value, which will be subjected to maintenance on a regular basis, will constitute the main research facility of the laboratory, just like at the present moment. The teams will undergo a reshuffle due to the fact of ageing, however, it is of key importance that the acquired knowledge and experience may

be passed on to new team members and further pursued by them. This subject-matter will be of scientific interest in the following two decades.

With regard to premises, it is necessary to highlight that we do not foresee to build new premises within the area of the "Ochota" campus, we rather anticipate the necessity to modernise and perhaps rebuild the existing facilities to adjust them to new technical requirements.

7. Description of the conceptual framework for international cooperation on project implementation.

The description should include, in particular, the following aspects:

- *the possibility of implementing the project within the international framework of cooperation, including under the initiatives recognised by the European Strategy Forum for Research Infrastructures (ESFRI) as being of critical importance;*
- *the plan to develop international cooperation on the basis of the proposed research infrastructure, including the measures to be taken to "attract" foreign scientific staff.*

As mentioned above, this project is a part of the implementation of the concept of the European ECOS consortium. It is therefore in line with European structures. One must not expect, however, that it will be considered as strategic by the European Strategy Forum on Research Infrastructure. It will, to a larger extent than the present HIL, participate in the development of international scientific cooperation and international business entities will be interested in taking advantage of its possibilities.

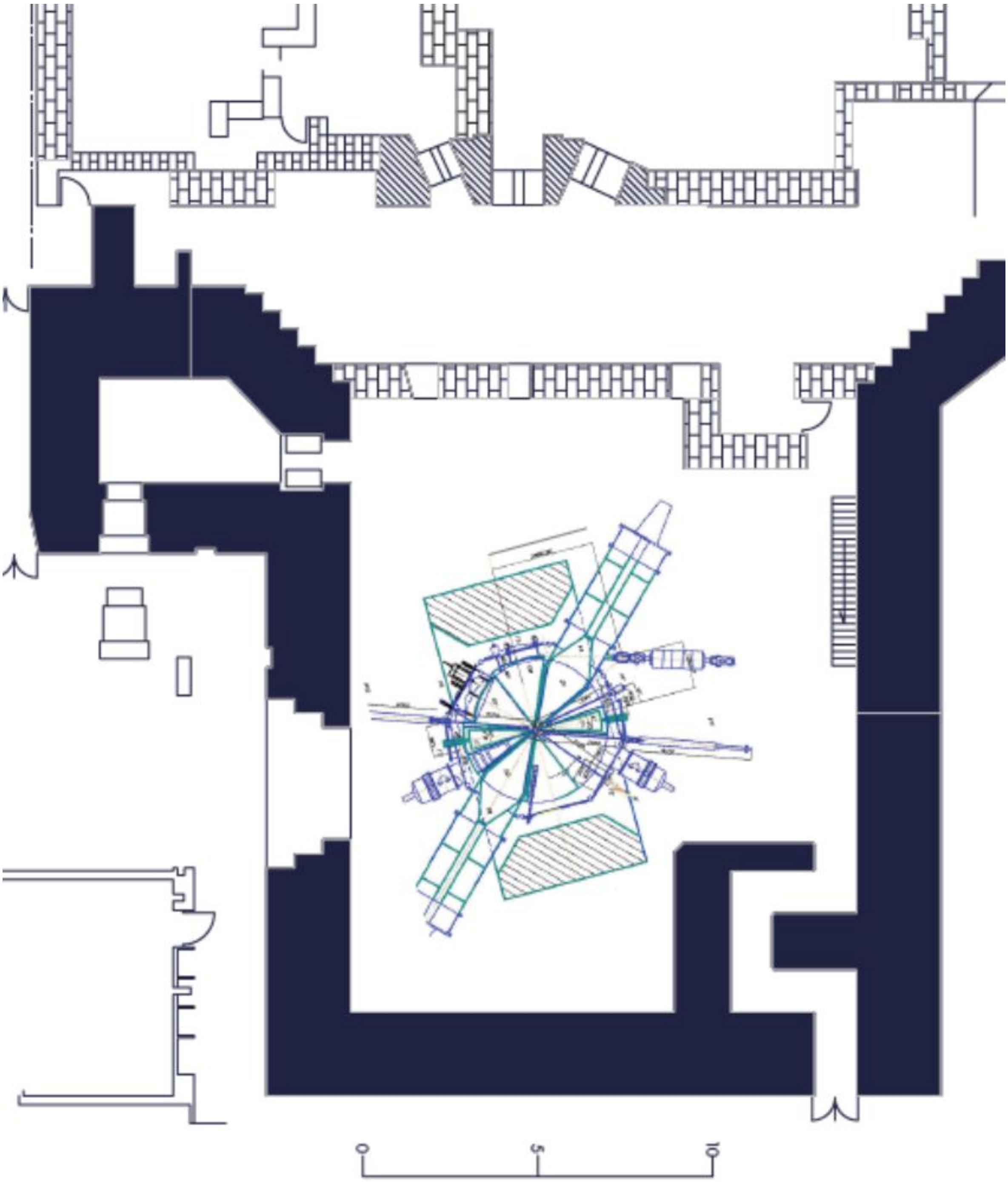
International organisations mention our laboratory in the following key documents:

1. NuPECC Long Range Plan 2017, Perspectives in Nuclear Physics, p. 27;
2. NuPIA Opening-up of nuclear Physics Laboratories to the industrial sector; ENSAR2 document.

We expect that raising the intensity of the accelerated beams as well as a diversification of the accelerated ion species will result in an increased submission of proposals for new experiments from both domestic users and those from abroad. The expected reliability of our new machine as well as its considerable experimental possibilities will in particular place our facility in a position to host highly developed but moveable European detector infrastructures (such as the Advanced GAmma Tracking Array - AGATA) for particular series of measurements. We already take advantage of these possibilities, performing experiments with detectors owned by the GAMMAPOOL consortium; we anticipate an expansion of such collaborations towards different, more advanced experimental apparatus.

Another important aspect of expanding international cooperation is the possibility to finance the accommodation of foreign scientists. We have extensive experience in this field: within the framework of the ENSAR2 project our laboratory receives so-called TNA-Transnational Access financing which covers the accommodation expenses of guests from abroad who perform research at our accelerator. We hope that the amount of financing will considerably increase via an adequate European project when the operation of our new accelerator is launched.

8. Other relevant information necessary to evaluate the application (no more than 2 pages).



An exemplary positioning of the DC-280 cyclotron in our current bunker where the U-200P cyclotron is currently set up.

NuPECC
Nuclear Physics European Collaboration Committee

Caen, June 11, 2018

Prof. Krzysztof Rusek
Director of SLCJ
Warszawa

Dear Krzysztof,

With this letter I would like to express a strong support of NuPECC for the new initiative ŚLCJ@ECOS which is proposed for the new edition of roadmap of research infrastructures in Poland. This initiative is directly in line with the recently published NuPECC Long Range Plan in Nuclear Physics http://www.nupecc.org/lrp2016/Documents/lrp2017.pdf and the ECOS initiative http://www.nupecc.org/index.php?display=ecos/ecos. The proposed construction of a new high-intensity accelerator in Warsaw would open exciting new possibilities for research in fundamental nuclear physics (ex. study of Super Heavy Elements) and in numerous, in particular medical applications. The ŚLCJ@ECOS will allow hosting the most advanced detection systems (ex. AGATA, PARIS and NEDA) developed by international consortia and used today at other European infrastructures. This ambitious project will also reinforce the position of Polish nuclear physics community in Europe and largely increase capabilities of training of young researchers and engineers in Poland.

Sincerely yours,

Prof. Marek Lewitowicz
NuPECC Chair
GANIL, Caen, France

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European Science Foundation

9. Full name, phone number and e-mail address of the person responsible for drafting the application.

Krzysztof Rusek,+48 (22) 55 46 342, rusek@slcj.uw.edu.pl

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