University of Warsaw

Heavy Ion Laboratory

Annual Report

2010

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Annual Report of the
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The photo on the title page was taken in front of the HIL building on 17 June 2011. See page 97 for names.

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Introduction

This year was a year of hope for change. We attempted to become one of the laboratories of the "Road Map of National Research Infrastructure" of the Ministry of Science and Higher Education (MNiSW) of Poland. At the beginning of the year we were informed by the MNiSW that we had passed the first selection with the suggestion that we prepare, as the next step, a joint project with the H. Niewodniczański Institute of Nuclear Physics of the Polish Academy of Science (IFJ) in Cracow. On the 21st of April the Rector of the University of Warsaw and the director of IFJ created the consortium "National Cyclotron Laboratory", signing an agreement between our two institutions. In this way the two largest nuclear physics institutes in Poland, with two operating cyclotrons (a proton cyclotron in Cracow and the heavy-ion cyclotron in Warsaw) and two others becoming operational within the next two years, united their efforts and prepared a common project devoted to fundamental research in nuclear physics and its medical applications. Unfortunately, our project was not selected for the "Road Map" — a decision of the MNiSW incomprehensible to us. Since such a document must be regularly updated we will continue our efforts to find a place on the national "Road Map".

Despite our lack of success in our own country, on the European level our laboratory was recognised by the Nuclear Physics European Collaboration Committee (NuPECC). This important international body released in December the "NuPECC Long Range Plan 2010, Perspectives of Nuclear Physics in Europe". Our laboratory is listed among other European small scale facilities with the recommendation — "These national and other university based facilities are needed for specific experimental programmes, development and testing of new instruments and to provide education of next-generation researchers from university groups".

It was not an easy year for experimentalists. In the spring the new Supernanogan ECR ion source was installed and during the installation period beam from the cyclotron was not available for users. The source was commissioned in May but its coupling with the cyclotron requires some additional changes to the cyclotron injection system. These will be introduced in summer 2011 and accelerated beams from the new source should be available for experiments in the second half of 2011.

Due to the installation of the new source, the spring experimental campaign was limited to a few weeks in June and the beginning of July. Nevertheless, we would like to welcome new users — a group of physicists from the University of Ioannina, Greece, led by Prof. Athena Pakou and an international team led by Dr. Marcus Scheck.

In September, construction work on new buildings for the Faculties of Physics, Biology and Chemistry started in earnest in the immediate neighbourhood of our laboratory. This caused many unexpected cuts in the power and water supplies and, in addition, some flooding in the basement of our building. We were therefore forced to limit our activity and postpone a series of planned experiments to the first half of 2011.

Fortunately, in October we were still able to run some simple experiments for the 6th edition of the Polish Workshop on Acceleration and Applications of Heavy Ions, a one week event for undergraduate students from Polish universities. From 2011 onwards, this activity will be extended — we will organise an annual two-week workshop for students from abroad within the framework of the Erasmus — LLP Intensive Programme. This initiative has received the necessary funding from the Polish National Agency of Erasmus — the Foundation for the Development of the Educational System Lifelong Learning

Programme. The workshop will be organised jointly with the University of Sofia, Bulgaria, and the University of Huelva, Spain.

It does not happen every year so I would like to mention that the Heavy Ion Laboratory co-organised an international conference, the 17th Nuclear Physics Workshop "Marie & Pierre Curie". The general subject was "Symmetry and symmetry breaking in nuclear physics". The conference took place in Kazimierz Dolny, from 22nd till 26th of September and attracted about seventy scientists from various countries.

Our PhD students are among the best at the University of Warsaw. Katarzyna Hadyńska-Klęk was awarded a prestigious research scholarship funded by the European Social Fund in the framework of the Human Capital Programme.

The greatest news came at the end of the year — our project "Purchase and installation of two HF generators for the Warsaw U-200P cyclotron" obtained full funding from the MNiSW. Thus, by the end of 2013 we should have exchanged our very old and worn out generators by new ones. After almost twenty years of constant activity this message brings a new lease of life to our laboratory.

Prof. Krzysztof Rusek, Director of HIL

Part A

Laboratory overview

A.1 General information

K. Rusek, J. Choiński, M. Zielińska

Heavy Ion Laboratory, University of Warsaw, Warszawa, Poland

Heavy Ion Laboratory (HIL) is a part of the University of Warsaw, the largest university in Poland. HIL was founded jointly by Ministry of Education, Polish Academy of Sciences and Polish Atomic Energy Agency. It is the largest experimental nuclear physics laboratory in the country, equipped with a K=160 heavy-ion cyclotron, unique not only in Poland, but also in Central Europe.

The first beam was extracted in 1993 and since that time HIL is an effective "user facility", serving up to the present time over 350 scientists from Poland and abroad and becoming a recognised element of the European Research Area. Beam time is allocated by the Director based on the recommendation of the international Programme Advisory Committee (see Sec. D.8). The only criteria are the scientific merit of the project and its technical feasibility. The research programme (see Part B) is mostly focused on nuclear and atomic physics, but also materials science, biological and application studies play an important role and a significant amount of the beam time is allocated for these purposes.

Experimental teams may take advantage of permanent set-ups installed on the beam lines or use their own dedicated equipment. Available apparatus includes IGISOL — a Scandinavian type on-line separator, CUDAC — a PIN-diode array particle detection system, JANOSIK — a multidetector system consisting of a large NaI(Tl) crystal with passive and active shields and 32-element multiplicity filter and ICARE, charged particles detector system used for their identification and energy measurements, moved to HIL from IReS Strasbourg. The most recent experimental tool, still being developed and improved, is the EAGLE array (Sec. A.10) – a multidetector γ-ray spectrometer, which can be easily coupled to ancillary detectors like an internal conversion electron spectrometer, a charged particle 4 π multiplicity filter (Si-ball), a scattering chamber equipped with 100 PIN-diode detectors, a 60-element BaF_2 gamma-ray multiplicity filter, a sectored HPGe polarimeter and a plunger.

HIL is currently in a transition period and will shortly become an accelerator centre, operating two cyclotrons (Sec. A.3). Installation of a commercial proton-deuteron cyclotron ($E_p = 16.5$ MeV) is under way in the HIL building. This accelerator will be used for the production of and research on radiopharmaceuticals for the Positron Emission Tomography (PET). Production of long-lived radiopharmaceuticals for other medical and life-science applications is also foreseen.

A.2 Operation and improvement of the cyclotron in 2010

J. Choiński, A. Bednarek, P. Gmaj, W. Kalisiewicz, M. Kopka, B. Paprzycki, O. Steczkiewicz, J. Sura

Heavy Ion Laboratory, University of Warsaw, Warszawa, Poland

Altogether 1598 hours of beam were successfully delivered to different experiments over the 2010 year. The total beam on target time was lower compared to previous years. There are several reasons of such situation and they are mentioned below. Fig. 1 shows the usage of cyclotron beams over the last eleven years and Fig. 2 presents distribution of the beam time per month in 2010.

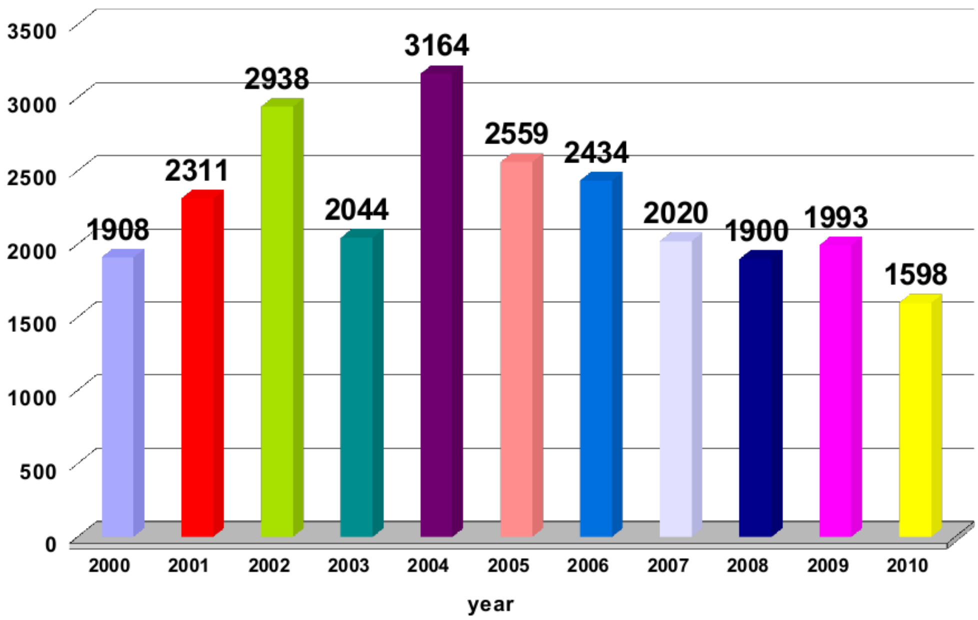

Figure 1: Total cyclotron beam time in years 2000–2010.

One of the reasons of difficulties in the daily operation of the cyclotron was the ageing vacuum system — this problem was already mentioned in the HIL Annual Report 2010. Unfortunately, our attempts to acquire funds for the modernisation of this system were not successful so far. A new grant application will be submitted in 2011.

The spring break in the operation of the cyclotron (April–May) was mostly due to the installation of the new Supernanogan ECR ion source and its horizontal beam line, which were commissioned in May. The beam line between new ECR ion source and the cyclotron injector was also provided by Pantechnik, in addition to the ECR ion source. Since the line performance was not satisfactory, several investigations were carried out to improve its efficiency. It turned out that the influence of the cyclotron stray fringe magnetic field on the magnetic components of the line (bending magnets) caused almost utter beam loss. Three additional steerers were added and put into operation, which improved performance of the line dramatically. Further improvements of the line transmission are planned for 2011. The new ECR ion source requires also some changes in the injection system (inflector, cyclotron central geometry). Therefore, a new mirror inflector, optimised for the injection voltage of the new ECR source, was designed. The

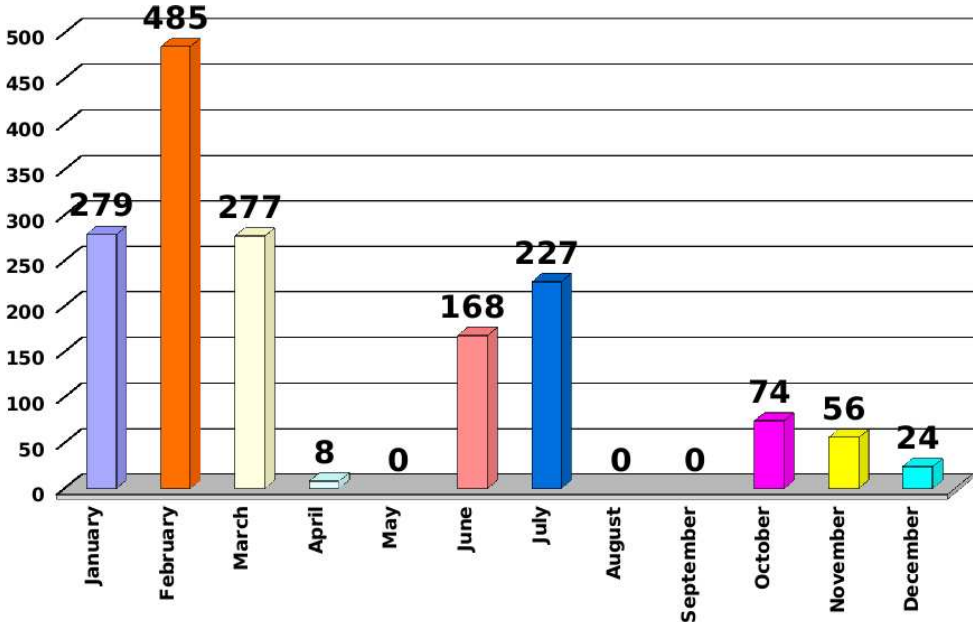

Figure 2: Beam time distribution (hours) in 2010 per month

optimisation calculations were performed using the Mathcad software. The new inflector will be installed in summer 2011.

After the traditional summer break in August, the Laboratory suffered from the disturbances caused by the construction of two new university buildings in our nearest neighbourhood. These works forced rebuilding of the systems supplying to the laboratory electricity, water, as well as of the sewage systems. The central heating system and a few other infrastructure services of the Ochota Campus were also affected. For this reason the management of HIL decided to strongly limit the experimental activity in autumn — only few experiments were run.

Diversity of the experiments performed in 2010 is presented in Fig. 3. As in previous years, the main topics of the experiments are related to nuclear physics research. A fair share of the beam time was also allocated to other research domains: the program of radio-biological studies using heavy ion beams was continued, and traditionally a week of beam time was allocated to a student workshop. The machine tests and development also used a significant part of the beam time. In all the experiments, the involvement of young researchers, graduate and undergraduate students is traditionally large, which is illustrated in Fig. 4. Detailed description of the experimental set-ups available at HIL can be found in the laboratory web page `www.slcj.uw.edu.pl`.

A list of the experiments performed in 2010 is presented in Table 1. The following acronyms of the institution names are used in the table:

- AMU Poznań —- Adam Mickiewicz University, Poznań
- IB JKU Kielce – Institute of Biology, Jan Kochanowski University, Kielce
- HU Cambridge — Harvard University, Cambridge, USA
- HCC, Kielce – Holycross Cancer Centre, Kielce
- IEP UW — Institute of Experimental Physics, University of Warsaw, Warsaw
- INP Kraków — The Henryk Niewodniczański Institute of Nuclear Physics, Polish Academy of Sciences, Kraków

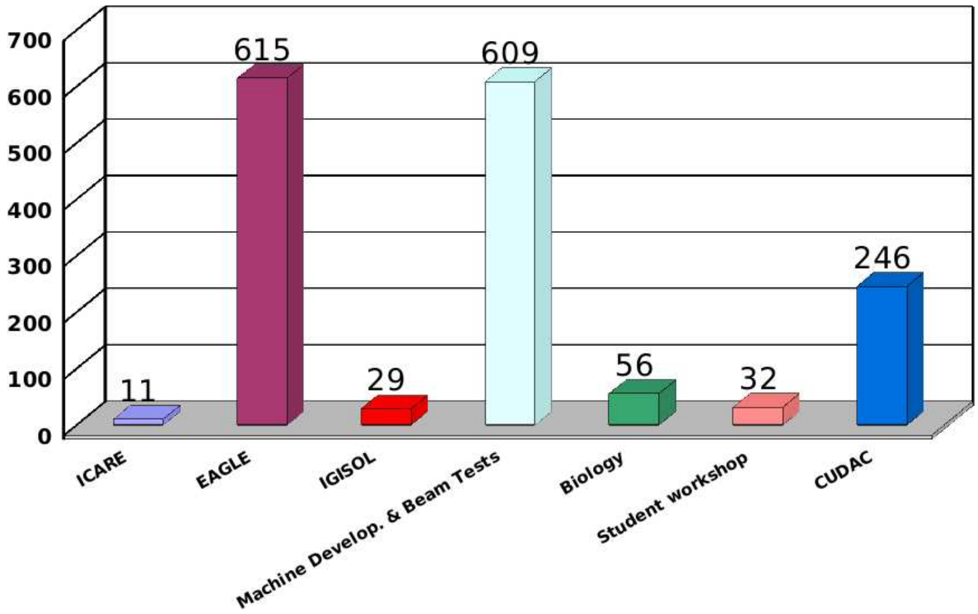

Figure 3: Distribution of beam-time (in hours) among different experiments

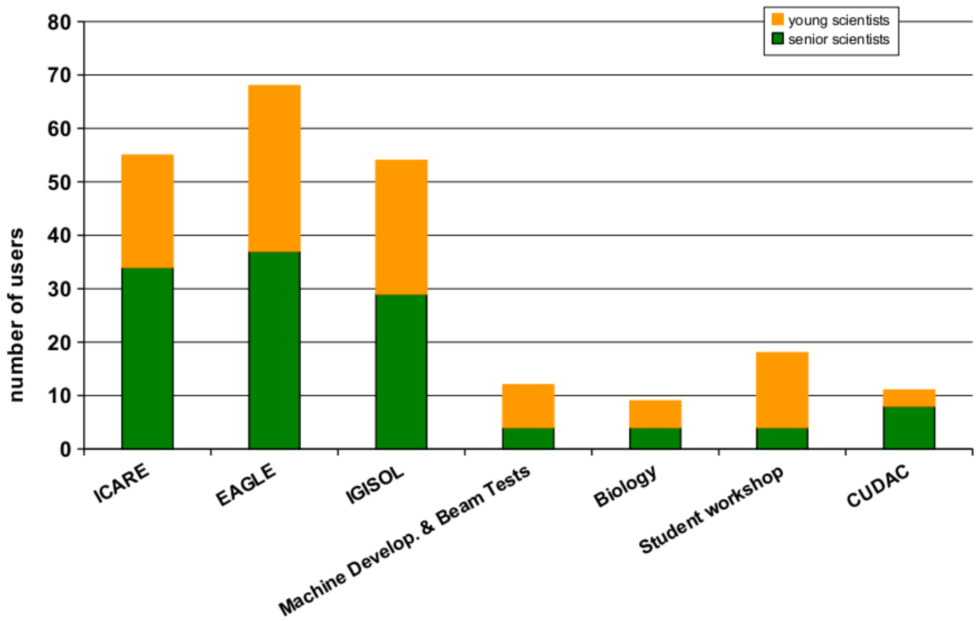

Figure 4: Users of the Warsaw cyclotron beams in 2009

- IPN Orsay — Institut de Physique Nucléaire, Orsay, France
- SINS Łódź — The Andrzej Sołtan Institute for Nuclear Studies, Łódź
- SINS Świerk — The Andrzej Sołtan Institute for Nuclear Studies, Świerk
- MCSU Lublin — Maria Curie-Skłodowska University, Lublin
- NU Kharkiv — National University, Kharkiv, Ukraine
- NCU Toruń — Nicolaus Copernicus University, Toruń
- UI Ioannina — University of Ioannina, Greece
- UL Liverpool — University of Liverpool, Liverpool, UK
- US Katowice — University of Silesia, Katowice

Table 1: Experiments performed in 2010

Dates	Ion Energy	Experiment	Leading institution	Collaborating institutions
11.01–15.01	$^{14}N^{+3}$	Test of the upgraded injection beam line	HIL	
18.01–21.01	$^{18}O^{+4}$ 100 MeV	IGISOL	IEP UW	HIL, SINS Świerk, SINS Łódź, US Katowice, IPN Orsay
25.01–05.02	$^{20}Ne^{+5}$ 150 MeV	EAGLE	HIL	IEP UW, SINS Świerk
08.02–19.02	$^{20}Ne+^{3}$ 50 MeV	CUDAC	HIL	SINS Świerk, NU Kharkiv, US Katowice, INP Kraków
22.02–26.02	$^{12}C^{+3}$ 50 MeV	EAGLE	SINS Łódź	HIL, SINS Świerk, SINS Łódź, IEP UW
01.03–03.03	$^{12}C^{+3}$ 50 MeV	Biology	IEP UW, IB JKU Kielce	HIL, HCC Kielce, SINS Świerk, NCU Toruń
10.03–19.03	$^{20}Ne^{+3}$ 90 MeV	EAGLE	UL Liverpool	HIL, Univ. of Yale, Univ. of Kentucky, TRIUMF, IEP UW, SINS Świerk
21.06–25.06	$^{20}Ne^{+3}$ 55 MeV	CUDAC	HIL	SINS Świerk, NU Kharkiv, US Katowice, INP Kraków
28.06– 29.06	$^{12}C^{+3}$ 50 MeV	Biology	IEP UW, IB JKU Kielce	HIL, HCC Kielce, SINS Świerk, NCU Toruń
05.07–11.07	$^{20}Ne^{+3}$ 54 MeV	EAGLE	HIL	IEP UW, SINS Świerk, Harvard Univ.
12.07– 13.07	$^{20}Ne^{+3}$ 54 MeV	ICARE	UI Ioannina	HIL, IEP UW, SINS Świerk
14.07–29.07	$^{16}O^{+4}$	Test of the new ion source and of the injection beam line	HIL	
25.10– 28.10	$^{20}Ne^{+3}$ 54 MeV	Student workshop	HIL	
05.11–17.12	$^{16}O^{+4}$	Test of the new ion source and of the injection beam line	HIL	

A.3 The Warsaw PET Project — Radiopharmaceuticals Production and Research Centre at HIL

J. Choiński, J. Jastrzębski, K. Kilian, I. Mazur, P.J. Napiorkowski, A. Pękal, D. Szczepaniak

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Information on the Warsaw Consortium for PET Collaboration (WCPC), the Warsaw PET Project and its Radiopharmaceuticals Production and Research Centre (RPRC) has been already presented in previous HIL Annual Reports [1] and is available on the project Web page [2]. In these communications, the problems encountered by the main Contractor (GE Medical Systems) with his Subcontractor (Block Zalup) were mentioned and the accumulated delays explained. In February 2010 the contract with the unreliable subcontractor was successfully terminated by GE and a new building construction company (M+W Process Industries) was introduced on the construction site. However, the legal negotiations between the Main Contractor and the new construction subcontractor lasted many months and the new contract was signed only on 8 August 2010. In parallel, a meeting of Project 4016/18 Parties was prepared and organised in the IAEA headquarters in Vienna on 19 October 2010. By a common agreement it was decided that the building construction contract between GE and University of Warsaw will be extended to allow the full completion of other contract terms. Finally, on 27 October 2010 the new time table was presented to the Investor and Annex I to the construction contract was signed between GE Medical System and University of Warsaw. In this document the new date for the full execution of the building adaptation works was fixed as 22 September 2011.

The Factory Acceptance Test (FAT) of the PETtrace cyclotron unit was carried out in Uppsala in presence of a University of Warsaw representative on 14–15 December 2010. The unit is shown in Fig. 1. Presently the building adaptation works are in progress and it is hoped that the completion date will be not much different from the one indicated in document mentioned above.

Bibliography

[1] J. Jastrzębski *et al.*, HIL Annual Report 2006, page 42
J. Choiński *et al.*, HIL Annual Report 2007, page 14
J. Jastrzębski *et al.*, HIL Annual Report 2008, page 15
J. Choiński *et al.*, HIL Annual Report 2009, page 14

[2] `http://www.slcj.uw.edu.pl/PET`

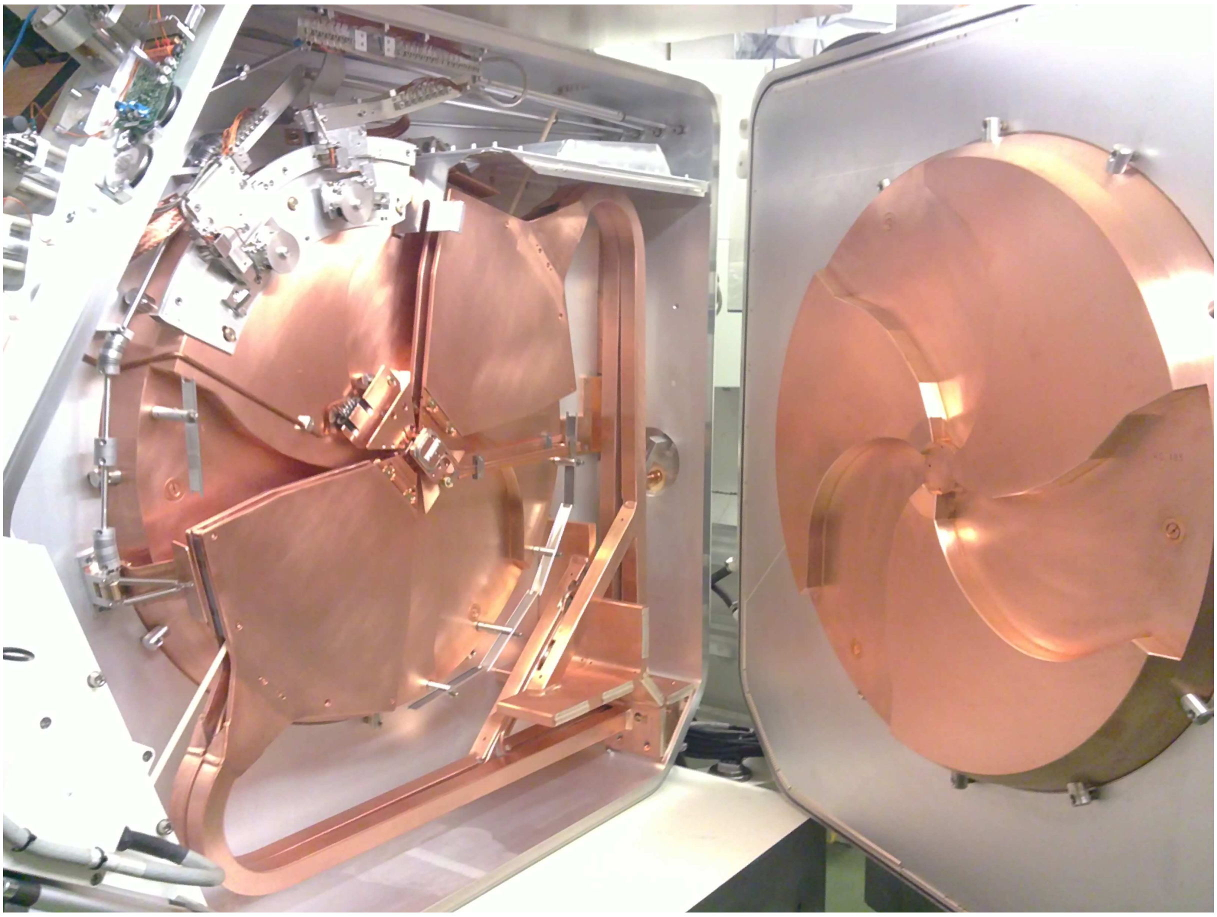

Figure 1: The PETtrace unit for the Warsaw Radiopharmaceuticals Production and Research Centre during the Factory Acceptance Tests in Uppsala.

A.4 Nuclear Cogeneration

L. Pieńkowski[1,2]

1) Heavy Ion Laboratory, University of Warsaw, Warszawa, Poland
2) AGH University of Science and Technology, Kraków, Poland

Nuclear Cogeneration refers to the simultaneous production of useful thermal energy and electrical energy using nuclear reactor as a heat source. A typical modern water-cooled reactor produces heat at a relatively low temperature, slightly in excess of 300°C. This limits the possibility of using nuclear reactors, which are available today, for electricity generation and low-temperature applications, for example as a heat source for district heating systems. High Temperature Reactors (HTR) are a new, but mature enough technology that can open in a near future (10 - 15 years) possibilities to provide process heat for many industrial processes. The market for industrial process heat today is at least of the same size as the electricity market, which is almost entirely based on combustion of fossil. New, emission-free heat source not only will reduce CO_2 emissions as well as consumption of natural gas and crude oil in refineries or fertiliser plants, but also will open an option of the chemical coal processing with strongly limited CO_2 emission, what is referred to as a nuclear-coal synergy. The formation procedure of the European nuclear cogeneration industrial alliance, being a next step after EUROPAIRS program, was under way in 2010. This alliance will consist of partners that use process heat, companies that can offer HTR technology and engineering companies supported by scientific institutions. Additionally, during last year the consortium Gen4Syn was formed in Poland to provide a complex start-up program in the field of nuclear cogeneration. Our Laboratory collaborates with the AGH University of Science and Technology in Kraków, which is a leader in both fields.

A.5 New ECR ion source and injection line

O. Steczkiewicz, J. Choiński, M. Wolińska-Cichocka, J. Jastrzębski, P. Napiorkowski, L. Pieńkowski, A. Górecki, A. Jakubowski, A. Pietrzak, M. Kopka, A. Bednarek, J. Miszczak, B. Filipiak, R. Tańczyk

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In October 2008 the second contract between Heavy Ion Laboratory University of Warsaw and PANTECHNIK S.A., concerning the purchase of elements of the SUPER-NANOGAN ECR ion source and the whole horizontal injection line, was signed. In December 2009 first elements of the injection line arrived to Warsaw. The new analysing magnet, three quadrupole magnets and the diagnostic chamber were installed, at this stage without cabling. In the beginning of March 2010 the Factory Acceptance Tests (FAT) of the ECR source were carried out in France. The source passed all the tests with positive results. In the end of March 2010 the lacking elements of the injection line and the complete ECR ion source were delivered to HIL. In-site installation of all the equipment, followed by the commissioning and training, were accomplished by the end of April 2010. During the Site Acceptance Tests (SAT) current, stability and emittance of oxygen, argon, tantalum and lead beams were measured. The new ion source with its horizontal part of injection line is shown in Figs. 1 and 2. Table 1 lists the guaranteed intensities of the ions produced by the source.

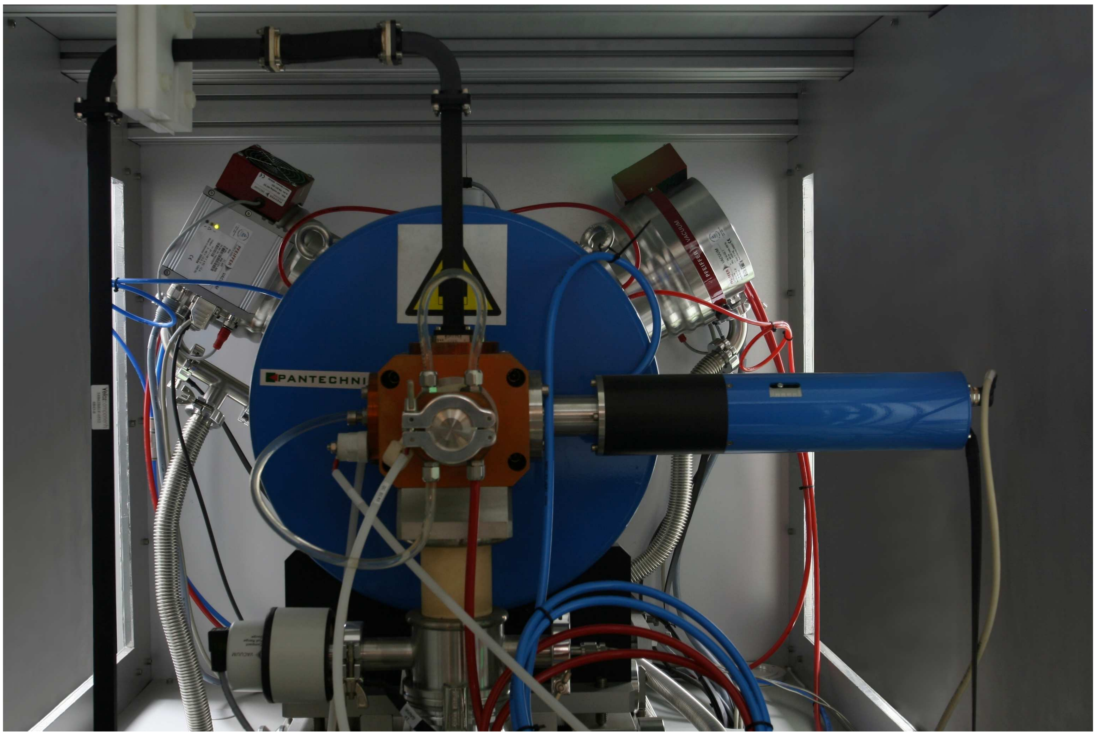

Figure 1: New ECR ion source with its shielding

Figure 2: New ECR ion source with the the horizontal part of injection line

ion/ charge state	+1	+2	+4	+6	+8	+9	+11	+14	+20
H_2	2000								
He	2000	1000							
C	500	350	200	3					
N	1000	300	100	10					
O	1000	400	300	200					
Ne	1000	300	200	160	25				
Ar	1000	350	250	200	200	90	30	1	
Kr	1000						25	15	
Ag			250	250	200	90	30		4
Xe	500				220				3

ion/ charge state	+20	+25	+26	+27	+30	+31	+32
Ta	4	0.8					
Au			10	6	1	0.7	0.2
Pb	10	5	3	1	1	0.7	0.2

Table 1: Guaranteed intensities of the ions produced by the new ECR source (in μA).

A.6 Design of a new hardware for the cyclotron control system

J. Miszczak, Z. Kruszyński

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An overview of the control system for the Warsaw Cyclotron was given in a HIL Annual Report 7 years ago [1]. Since then only minor modifications have been done to the system. However, during this period the PC hardware evolved a lot. Besides faster, multi-core processors, a new interconnect bus — PCI-Express — was introduced and quickly gained widespread support. At the same time support for the ISA bus was completely dropped off from PC motherboards.

Since almost all of the interface boards used by the HIL control system are ISA based, transition to the new standard had to be initiated, to assure reliability of the system in future. As a stopgap measure we stashed a few older computers, but otherwise in perfect working condition, equipped with ISA motherboards. Then we started looking for replacement interface boards. We discovered that digital-to-analog (D/A) and analog-to-digital (A/D) converter PCI or PCI-EXPRESS based boards are plentiful (albeit much more expensive than their ISA counterparts). It was also realised that multi port RS-232 boards are no longer available. As there are at least two dozens high current power supplies in use at the Warsaw Cyclotron that are controlled via RS-232, this indicated an imminent trouble. The custom in-house built ISA boards should also be replaced.

There are integrated circuits (IC) on the market that simplify designing and building custom PCI interface boards (like PLX 9050), but they tend to be expensive in single quantities. Therefore we decided to buy some digital input/output PCI boards and use their I/O signals as a secondary bus under software control from the computer host. Custom designed and built D/A, A/D timer and other interface boards connect to the secondary bus. The custom interface boards turned out to be significantly cheaper than interface board available on the market, since the custom boards do not have unneeded features of commercial boards. So far only the hardware part of the problem was addressed, the control software will also have to be changed. The work will continue in 2011 and very likely in 2012.

Bibliography

[1] J. Miszczak, J. Choiński, HIL Annual Report 2004, page 10

A.7 Modifications of the buncher

M. Sobolewski, J. Miszczak

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The sinusoidal buncher at the Warsaw Cyclotron was commissioned in 2001 [2]. The buncher offers up to 3 times increase of the ion current available at the target (compared to the buncher switched off), and performs flawlessly since 2001. The installation of the new ECR source [1] at HIL made it necessary to increase the voltage at the buncher electrodes by about 20% due to higher energy of ions produced by the new source.

The existing buncher design was successfully modified to allow bunching of ions from both the new and the old ECR sources. Roughly at the same time researchers at HIL expressed interest in heaving beams of ions in which only every N-th pulse is present relative to cyclotron RF frequency. A circuit in which the N number can be set to arbitrary value is difficult to build, but a sinusoidal buncher can be made to perform this type of work if N=2. A buncher just needs to be driven with half of a cyclotron RF frequency. Therefore not only the electrode voltage was increased, but also a 1:2 frequency divider was added to the buncher (and the switch to turn it on or off). The new mode of operation also requires a new set of bunching electrodes, and their installation is time consuming, so only preliminary tests were performed. The amplitudes of "unwanted" pulses were suppressed by about 20dB .

Bibliography

[1] O. Steczkiewicz *et al.*, this Report, page 17

[2] J. Sura *et al.*, HIL Annual Report 2001, page 13

A.8 X-ray spectrum measurements of the HIL cyclotron dee voltage

A. Bednarek, J. Kownacki, J. Sura, T. Bracha, W. Kalisiewicz, Z. Morozowicz, B. Paprzycki, K. Sosnowski

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Direct measurements of the peak RF voltage on the cyclotron dees are difficult, as the electric contacts of probes and their insulators change due to the sputtering effect, and this affects the voltage measured with a voltmeter. As an alternative, one can deduce the peak value of the dee voltage from the maximum energy of X-rays generated by the stopping of field emitted electrons, accelerated in the RF electric field between the electrodes [1,2]. The X-ray energy spectrum is continuous and decreases with increasing photon energy, reaching zero at the energy of the electrons generating the X-rays. The measurement of the electron energy is therefore made by measuring the X-ray spectrum and locating its end-point energy.

For the X-ray spectrum measurements of the dee voltage a proportional counter filled with Xe/CH_4 gas mixture was used. The energy calibration of the detector was performed using a ^{241}Am radioactive source. The measurement time depended on the applied RF voltage: at lower voltages it was necessary to measure for a longer time to acquire the necessary statistics. A background spectrum (without RF voltage) was also measured, showing a very low level of X-ray radiation.

The measurements were performed for each dee independently, at three values of the RF frequency which are most important for the daily operation of the HIL cyclotron: 12.51, 15.0 and 17.335 MHz. The examples of spectra obtained for various RF voltages at 15.0 MHz frequency are illustrated in Fig. 1. The X-ray measured and voltmeter voltages are compared in Table 1. A good agreement is observed for dee A, while for dee B, the RF voltage measured by the X-ray spectrum method dramatically differs (by 10-15 kV) from the value of the voltmeter voltage.

Bibliography

[1] J. Sura *et al.*, Report LNS, Catania, March 1995

[2] Q.W. Zheng *et al.*, Proceedings of the 2-nd Asian Particle Conference, China, 2001

frequency (MHz)	dee	voltmeter voltage (kV)	X-ray measured voltage (kV)
12.51	B	60	45
	B	66	51
	B	77	60
	A	66	66
15.0	A	60	56
	A	66	65
	B	60	49
	B	66	52
	B	72	62
17.33	A	60	60
	B	66	54

Table 1: Peak voltage of the dees measured using X-ray spectrum method compared with voltage measured using a voltmeter.

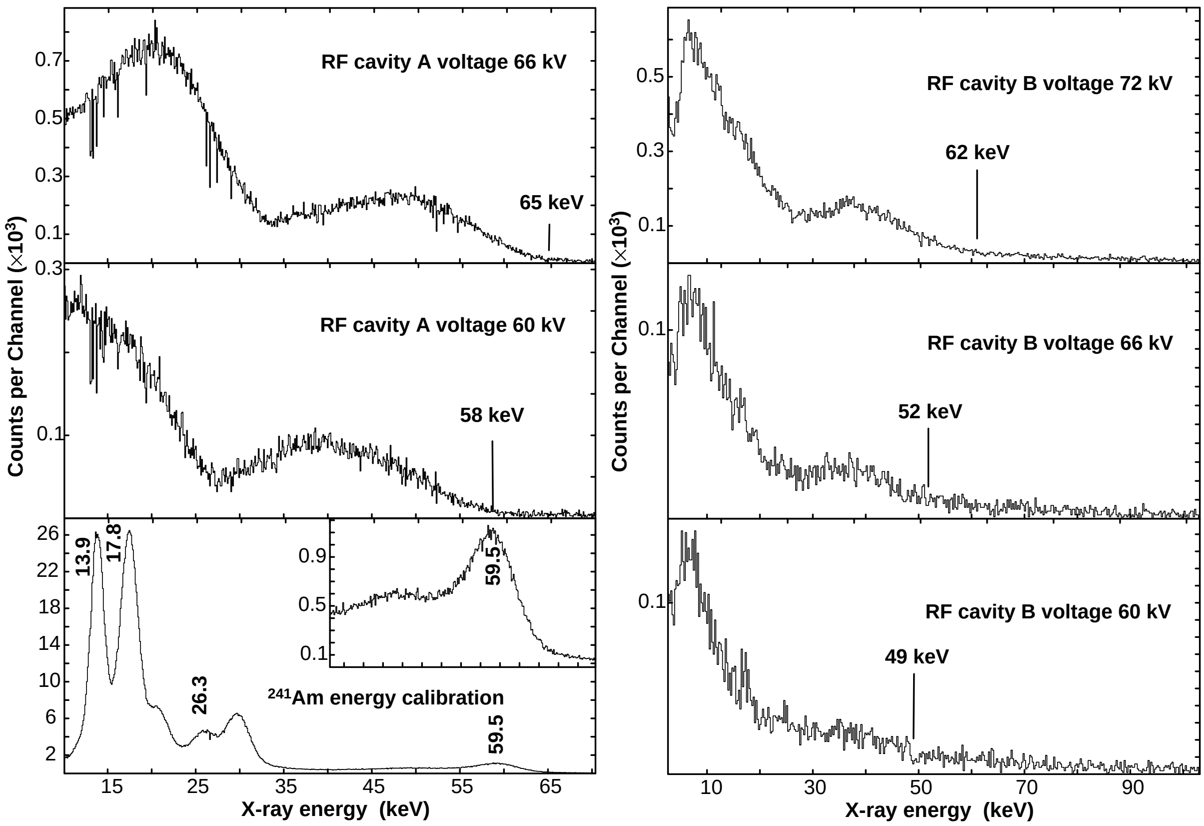

Figure 1: X-ray spectra for the two RF-cavities for three different voltmeter voltages (60, 66 and 72 kV) and the 15 MHz RF frequency. The ^{241}Am X-ray calibration spectrum is also shown. The measured voltages are marked in the plots.

A.9 Activity report of the electrical support group

M. Kopka, W. Kozaczka, P. Krysiak, K. Łabęda-Dyszy, Z. Morozowicz, K. Pietrzak

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The electrical support group in 2010 designed and implemented several projects:

1. Commissioning of the Danfisik DC power supply provided by the Sołtan Institute for Nuclear Studies. Connection of the device to the RCA switch board, installation of the cooling system and high-current cabling between the power supply and the switch for deflecting magnets.

2. Preparation of the documentation necessary for the realisation of reserve connections to the main switchboards (published as an internal report).

3. Contribution to the construction of the EAGLE stand.

4. Design, construction and installation of two steering electromagnets at the beam-line between the new ECR ion source and the T magnet. Detailed description of this activity was published as an internal report.

5. Construction of a mechanical ventilation system necessary to provide proper working conditions at the compressor cave (room 041). Works were described in an internal report.

6. Installation of cabling between the main earth electrode and the ZK 2 and ZK 3 monitoring connections.

7. Preparation of the documentation of additional earth electrodes of the HIL building installed in 2009 (published as an internal report).

8. Installation of a provisional power line for four fans in the cooling towers.

The following routine measurements and maintenance procedures were performed:

1. Measurements and maintenance of the electric power system and the electrical installation, including lighting inside and outside the HIL building.

2. Measurements and maintenance of power supplies, electromagnets and wiring of the laboratory equipment.

3. Measurements of the parameters of the electric power system of high frequency generators. Results were published as an internal report.

The above mentioned internal reports are listed in Sec. D.4.3.

In addition, five members of the electrical support group performed regular cyclotron operator duties according to the experimental schedule and participated in the science popularisation and teaching activities at HIL (guided tours of the facility, Polish Workshop of Acceleration and Applications of Heavy Ions, Festival of Science).

A.10 Central European Array for Gamma Level Evaluation (EAGLE) in-beam of the Warsaw Cyclotron at HIL UW — status report

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The EAGLE array (central European Array for Gamma Level Evaluations) is designed as a multi-configuration detector setup adjustable to the needs of several research groups, dealing with different branches of nuclear physics, gathered around the Heavy Ion Laboratory, University of Warsaw. In the present configuration (EAGLE Phase I) the array is equipped with 12 anti-Compton shielded HPGe detectors (see Fig. 1) of 20–35% efficiency and, depending on the type of measurements performed, coupled to ancillary detectors such as SiBall [1], conversion electron spectrometer [2] and Coulex scattering chamber [3].

The present EAGLE equipment will be soon complemented by 20 Euroball Phase-I HPGe detectors loaned by the European GammaPool. The arrival of detectors is scheduled for June 2011, and first experiments with the full EAGLE Phase-II array are planned for autumn 2011.

To fully benefit from the new configuration of the array, upgrades of the data acquisition and LN_2 filling systems were necessary. These works are progressing thanks to significant funding (about 800 kEUR) from the Polish Ministry of Science and Higher Education that was obtained by the EAGLE collaboration at the end of 2009 as a support for the research project “Nuclear symmetries and their spontaneous breaking — in-beam experiments at the HIL cyclotron” (years 2010–2012).

The construction of the new LN_2 cooling system was started in 2010. The existing outer tank of 10 m^3 volume has been renovated and a vacuum line of about 50 m length connecting it with the EAGLE manifolds was designed, as well as the control system for LN_2 auto filling. The construction was completed in March 2011 (see Ref. [4]).

In 2010 two test COULEX measurements were performed using EAGLE I equipped with 12 Ge detectors and 30 P-i-N Si diodes: ^{94}Zr and ^{104}Pd were Coulomb excited by the ^{20}Ne beam. In these experiment, a compact scattering chamber, redesigned recently, was demonstrated to work correctly.

New conversion electron spectrometer with 12 Si detectors has been tested. The commissioning took place in May 2011.

Two successful experiments to study complete and incomplete fusion reaction mechanism in $^{122}\mathrm{Sn}(^{20}\mathrm{Ne}, 6n\alpha)^{132}\mathrm{Ce}$ reaction at the beam energy of 150 MeV were performed. EAGLE I (12 Ge ACS) and SiBall (80% of the full solid angle) worked in a coincidence mode.

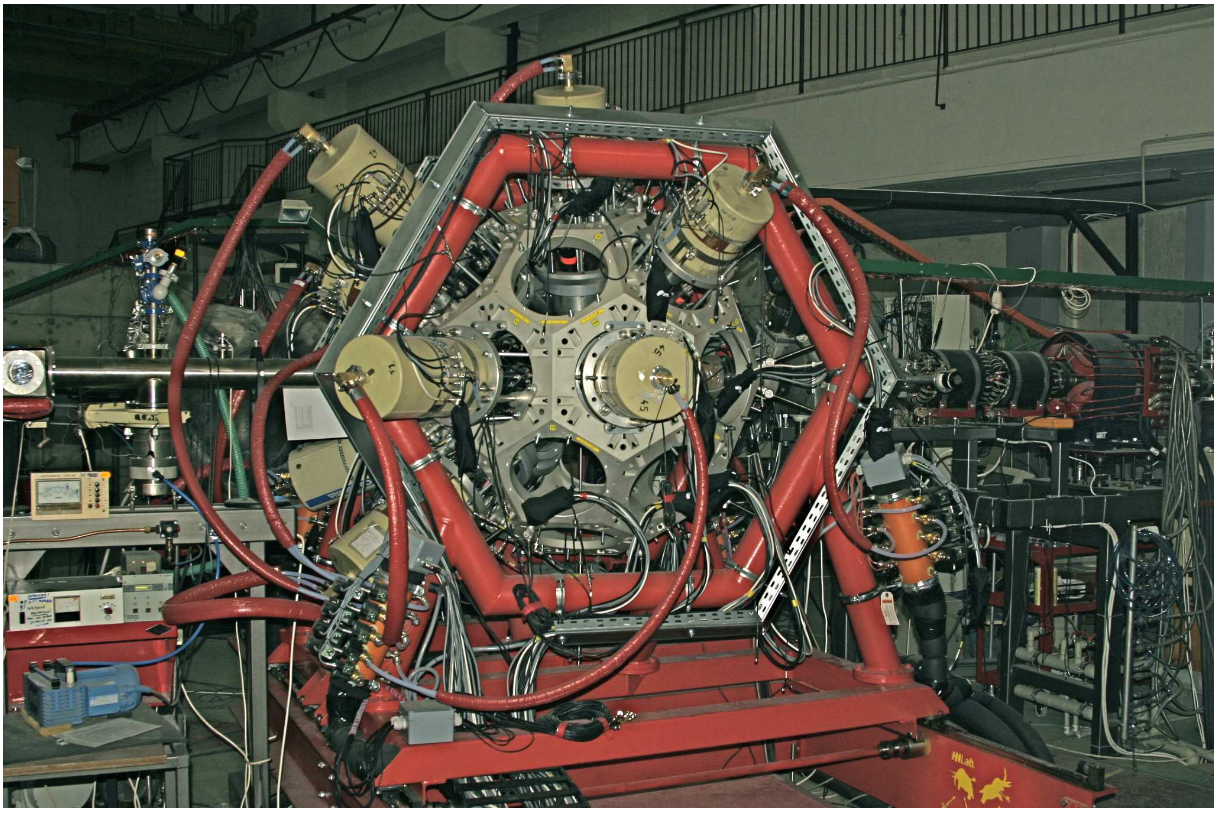

Figure 1: The EAGLE Phase I γ-ray spectrometer in the experimental hall of HIL.

The first DSAM lifetime measurement with EAGLE (test run for the chirality study in ^{124}Cs) was performed in March 2011.

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A.11 New liquid nitrogen filling system for the EAGLE array

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A new liquid nitrogen cooling system for the EAGLE array was designed and constructed in 2010. Its installation continued in the beginning of 2011, and the entire system was commissioned in March 2011.

Liquid nitrogen is supplied from an outside storage tank of 10000 litres volume through a vacuum insulated pipe more than 50 m long. The distribution to the individual detectors proceeds via elastic Teflon transfer tubes from four heat insulated manifolds. Each manifold can serve up to eight detectors, but recent tests have shown that due to pressure related issues it is better not to fill more than one cryostat from each manifold at the same time. The system includes several components located near EAGLE: an emergency stop switch, the I/O interface Programmable Logic Controller (PLC) and the Human-Machine Interface (HMI) touch pad. All control actions are performed via the HMI touch panel equipped with user friendly software. The system fills detectors every 8 hours, performs force filling if a detector warms up, keeps a full log database of detector diagnostics, temperatures, warnings and errors, as well as auto restarts if a crash occurs. It also enables the user to manually operate the filling cycle and monitor its status by issuing phone and e-mail notifications about alarm states.

Fig. 1 shows a schematic drawing of the installation. The filling cycle starts with opening the main valve (MAINVAL) and then the four manifold purge valves (PURGE) to cool the LN_2 transfer line until the LN_2 is detected by the MANITEMP sensors, or the filling timeout (parameter) is reached. In the second case the filling must stop and the alarm is set. If the transfer line is ready, the system opens detector valves DETVAL if a temperature rise in Ge dewars is detected or if the declared time from the last filling is exceeded. Filling should continue until the FILLED sensor detects LN_2 or a timeout is reached (alarm). If $n \geq 3$ consecutive detector fillings do not lead to detector cooling, the system should set an alarm. After the filling is completed, the MAINVAL valve stays open for 10 minutes in order to reduce the remaining LN_2 in the transfer line. The system then closes the MAINVAL valve and opens the distribution purge valves PURGE to out-gas. All sensors and valves are connected to the Programmable Logic Controller (PLC) unit, controlled by the Human-Machine Interface (HMI) touch panel. Monitoring of the set-up is possible via Ethernet and short notifications are sent via GSM.

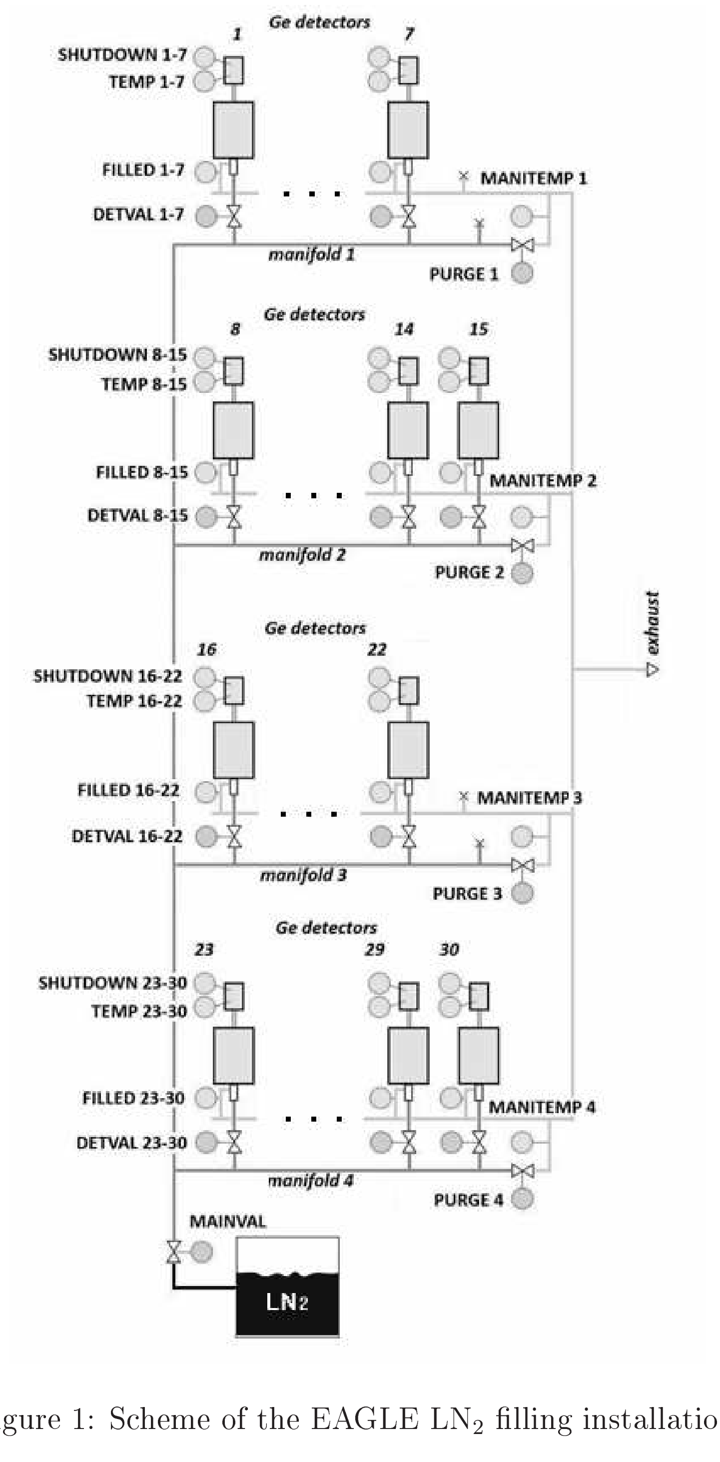

Figure 1: Scheme of the EAGLE LN_2 filling installation.

A.12 Unix Computers and Computer Network at HIL

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Modernisation and unification of all Unix computer systems used at HIL, started in 2009, was continued in 2010. Ubuntu Linux v. 10.04 was chosen as the target operating system. All workstations and most of the servers in the HIL computer network were upgraded to this operating system. In order to keep all the computers up-to-date, the systems are automatically updated once a week and after this operation computers are automatically restarted, if needed.

To minimise and make administrative work easier a number of shell scripts were written. The first group of scripts was designed to keep the Ubuntu hosts configuration coherent. Changes like modification of the configuration files or installing additional software packages that are common to all hosts are not performed manually on every computer but are coded in the appropriate scripts and stored in the repository (version control system). Each host automatically updates local copy of the repository once a day and invokes the administrative scripts. In this way all needed changes are automatically spread out through the whole network.

The second set of scripts uses a similar mechanism and was designed to make the process of system re-installation easier and faster (after hardware failures for example). There are two components of the mechanism which must be created for each host: the list of crucial files (configuration or data), and the repository where these files are stored. Every host automatically updates the list of files once a day and accordingly updates local copy of the repository. After that the content of the repository is committed to the version control server. In this way, copy of the newest version of all crucial files for each host is stored and could be easily retrieved if system re-installation is needed. The scripts described above will be further improved and developed during 2012.

The Collaborative SPIRAL2 Project Preparatory Phase web site was modified. This site is hosted and maintained by HIL since 2009. In the first quarter of 2010 the visual design of the site was completely changed. In the middle of the year, the functionality of the site was extended by adding a specialised tool for building forms (claim forms, registration forms etc.) and by activating the RSS feed for selected parts of the site. The SPIRAL2 PP site was moved to the new server in the beginning of 2011.

A.13 Educational and science popularisation activities at HIL

A. Trzcińska[1], O. Steczkiewicz[1], M. Zielińska[1], M. Palacz[1], J. Choiński[1], K. Hadyńska-Klęk[1,2], G. Jaworski[1,3], K. Kilian[1], J. Mierzejewski[1,2], P.J. Napiorkowski[1], L. Pieńkowski[1], J. Srebrny[1], K. Wrzosek-Lipska[1,2],

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For many years the Laboratory has been strongly involved in education and science popularisation. Guided tours at HIL have become our regular activity. These "live" lessons on the cyclotron and nuclear physics continue to enjoy popularity in high schools, including ones from outside Warsaw. During the guided tour visitors can see the control room and the cyclotron, get acquainted with facilities installed in the Laboratory and experiments performed here. Short lectures providing basic introduction to the nuclear physics and principles of the cyclotron operation are also offered, especially to high school students. Tours are free of charge.

In 2010 we have attracted the highest number of visitors so far about 50 organised groups, which amounts to almost 1200 people. High-school classes were the largest category of our visitors, but we also welcomed students from various faculties of the University of Warsaw, including Physics, Chemistry, Biology and Mathematics, as well as from the Nicolaus Copernicus University in Toruń and the Warsaw University of Technology. Finalists of the Interschool Competition in Physics and Chemistry "EUREKA", participants of the Summer School of Physics and several groups of physics teachers were also among our visitors.

In 2010 for the 14th time, HIL participated in the annual Festival of Science. We organised a series of panel discussions on subjects related to nuclear physics and its applications in technology and medicine. These meetings took place in evenings from 20 September till 22 September and were accompanied by guided tours of the cyclotron. During the same week we also organised so-called Festival Lessons for secondary school classes. These simple lectures, addressed to youths of age 14–15, attracted large attention.

As a part of the pan-European event "Researchers' Night", a more informal presentation of our Laboratory was prepared in the evening of 24 September. We demonstrated various equipment from a nuclear physicist toolbox, starting from very simple and old, to modern and sophisticated ones. Every guest was invited to bring a potentially radioactive substance (e.g. soil, drinking water, building materials, food — any everyday use product) and the most active one has been chosen by open competition. Our visitors had an opportunity to talk to physicists and ask them all kind of questions, concerning not only the science, but also their motivations of choosing this career path.

The Sixth Polish Workshop on Acceleration and Applications of Heavy Ions was organised at HIL in October 2010 (see Sec. A.14 of this Report). HIL staff members are also engaged in supervising MSc and PhD theses — see Sec. D.1. In summer a four-week training was organised for several students from the Warsaw University of Technology.

A.14 Polish Workshop on Acceleration and Applications of Heavy Ions

P.J. Napiorkowski[1], *A. Trzcińska*[1], *T. Abraham*[1], *K. Hadyńska-Klęk*[1,2], *G. Jaworski*[1,3], *M. Kowalczyk*[1,2], *M. Palacz*[1], *J. Srebrny*[1], *O. Steczkiewicz*[1], *A. Stolarz*[1], *I. Strojek*[4], *K. Wrzosek-Lipska*[1,2], *M. Zielińska*[1]

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Polish Workshop on Acceleration and Applications of Heavy Ions is organised at HIL every spring since 2005. It is intended for third year physics students interested in nuclear physics, and offers them a unique opportunity to gain experience in methods of data acquisition and analysis, in operating the cyclotron including the beam diagnostics measurements, and in charged particle and gamma-ray detection techniques.

The number of participants has been increasing every year, reaching nineteen in 2008. After the success of the first editions, we usually receive over twice as many applications as the number of places available. It should be also noted that almost every year new institutions join the list of universities interested in sending their students to the Workshop. The participants are often willing to continue the collaboration with HIL in a form of a summer internship or at the MSc stage. So far three MSc theses prepared at HIL by former Workshop participants have been defended: one in 2008 at the Adam Mickiewicz University in Poznań and two in 2009 at the University of Silesia in Katowice.

The 19 students participating in the Workshop in 2010 came from the following universities: 6 from the University of Silesia, 6 from the Maria Curie-Skłodowska University in Lublin, 4 from the Gdańsk University of Technology, 2 from the Jagiellonian University in Kraków and one from the Adam Mickiewicz University in Poznań. During the Workshop they attended a series of lectures on subjects related to heavy ion physics. The experimental tasks allowed them to get acquainted with HIL infrastructure by performing measurements using dedicated apparatus available in the Laboratory. The Workshop was concluded by student presentations — each group prepared a 20 minute talk on their measurements and results.

In 2010, the programme of the lectures was the following:

- Radioprotection at HIL (R. Tańczyk),
- Introduction to heavy ion acceleration and elements of ion optics (O. Steczkiewicz),
- Detection of gamma radiation, charged particles and neutrons (M. Palacz),
- In-beam gamma spectroscopy (M. Zielińska),
- Targets for nuclear physics — how to prepare them? (A. Stolarz),
- Radiopharmaceuticals for Positron Emission Tomography (K. Kilian).
- Nuclear-coal synergy (L. Pieńkowski)

Students took part in the following experimental tasks:

- Beam focusing in heavy ion acceleration.
- Beam energy measurements based on the Rutherford scattering.
- Identification of excited bands in gamma-gamma coincidences.
- Gamma-ray measurements using scintillation detectors.
- Measurements of ^{137}Cs activity in environmental samples.

The first international edition of the Workshop on Acceleration and Applications of Heavy Ions took place at HIL in March 2011. A two weeks course for 19 participants was organised jointly by HIL, University of Huelva (Spain) and University of Sofia (Bulgaria) in the framework of the ERASMUS Intensive Programme.

A.15 17th Nuclear Physics Workshop "Marie & Pierre Curie", Kazimierz Dolny

J. Srebrny, M. Zielińska

Heavy Ion Laboratory, University of Warsaw, Warszawa, Poland

An international conference on nuclear structure theory, 17th Nuclear Physics Workshop "Marie & Pierre Curie", was organised in Kazimierz Dolny, Poland, on 22–26 September, 2010. The workshop general theme "Symmetry and symmetry breaking in nuclear physics" was related to the spontaneous symmetry breaking phenomenon, introduced to sub-atomic physics by Y. Nombu, Nobel Prize laureate in 2008.

This conference has been organised every year since 1993 by the Maria Curie-Skłodowska University in Lublin and Institut Pluridisciplinaire Hubert Curien (IPHC) in Strasbourg. Initiated as a working meeting of Polish and French nuclear structure theorists, the workshop was steadily gaining importance and currently it attracts about 70 scientists each year, who conduct both experimental and theoretical research in the field of nuclear physics.

This year, Heavy Ion Laboratory has joined the list of institutions co-organising the conference, which gathered participants from more than 20 countries, including China, USA, Japan, Canada, Republic of South Africa and numerous European countries. Two days of the meeting were devoted to subjects related to experimental studies performed at the Heavy Ion Laboratory: chirality and Coulomb excitation.

A special session was organised in memory of Władysław Świątecki, distinguished physicist of Polish origin. His achievements were presented by collaborators from all over the world, and his wife Uta was a guest of honour of the session.

More information on the 17th Nuclear Physics Workshop can be found on its website: `http://kft.umcs.lublin.pl/wfj/archive/2010`

Part B

Experiments at HIL

B.1 Barrier height distributions – the influence of weak channels

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The Barrier Collaboration continued investigations of the fusion barrier height distributions. The barrier distribution D_{qe} is obtained as the first derivative of the quasi-elastic excitation function σ_{qe} divided by the Rutherford cross section [1–3] for a scattering system.

In our experiments we have focused on the ^{20}Ne projectile, since this nucleus has extremely large deformation parameters: $\beta_2 = 0.46$, $\beta_3 = 0.39$, $\beta_4 = 0.27$ [4–6]. We have performed series of barrier distribution measurements for several targets: ^{112,116,118}Sn, ^{nat}Ni, ^{90,92}Zr and ^{208}Pb. The results of measurements were surprising: the barrier distributions for ^{20}Ne+^{112,116,118}Sn turned out to be smooth [7] in contradiction to the theoretical predictions, while for the ^{20}Ne+^{nat}Ni system a clearly structured distribution [8] was obtained (in a very good agreement with the calculations based on the coupled-channels method).

In a series of experiments [9] we have proved that excitation of the non-collective states of the system during backscattering of ^{20}Ne on Zr isotopes can give a rise to significant smoothing of the barrier height distributions D_{qe}. The first explanation of the influence of the non-collective excitations on D_{qe} can be found in [10]. Following the above conclusion and expecting that the higher density of levels should have a stronger impact on the smoothing of the barrier distribution, we have chosen three Ni isotopes for further investigations: ^{58,60,61}Ni. These isotopes have different level densities: ^{61}Ni has the highest one, whereas ^{58}Ni has the lowest. In 2010 the first measurements of barrier height distribution were performed for the ^{20}Ne+^{58,60,61}Ni systems.

A beam of ^{20}Ne was delivered by the Warsaw Cyclotron. We measured quasi-elastic backward scattering using the CUDAC chamber equipped with 30 PIN diodes of 1x1 cm^2 surface, placed at 130, 140 and 150 degrees in respect to the beam axis. Two PIN diodes placed at 35 degrees measured the Rutherford scattering. Ni targets of about 100 μg/cm^2 thickness were prepared from isotopically separated materials.

The preliminary results seem to be in agreement with our expectations (see Fig. 1): for ^{58}Ni, where the level density is low, the barrier distribution has a structure, whereas for ^{61}Ni, where the level density is higher, the structure at 37 MeV is smoothed out. The measurements were continued in the beginning of 2011 with a more intense beam in order to obtain better statistics.

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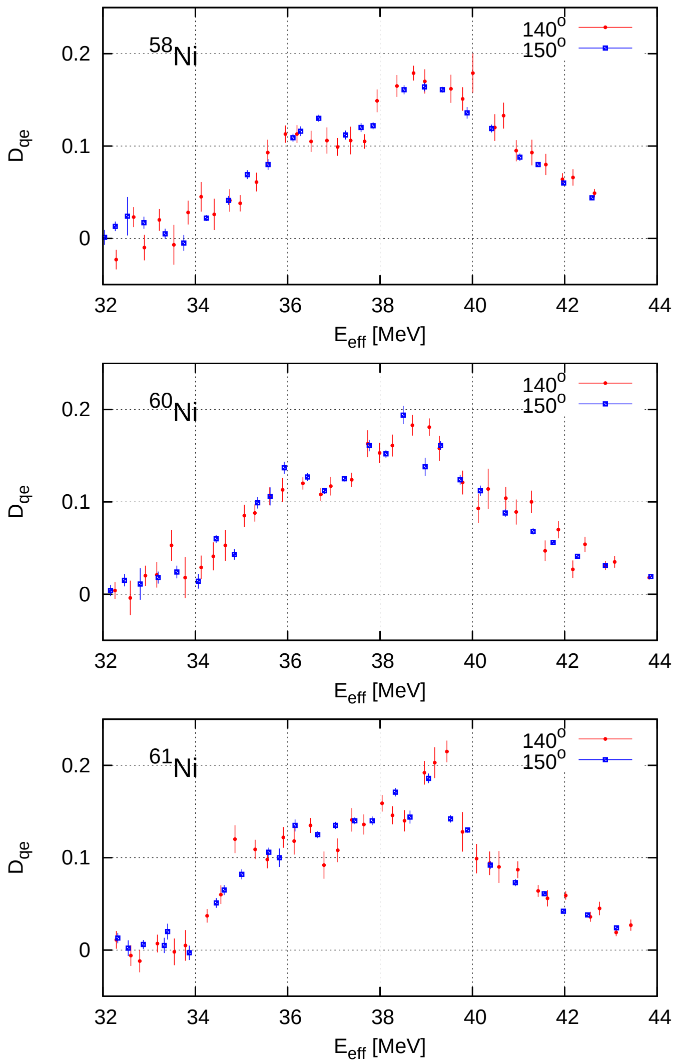

Figure 1: Preliminary results of the first measurements of barrier height distribution for the ^{20}Ne+^{58,60,61}Ni systems.

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B.2 Direct reactions of ^{20}Ne with ^{208}Pb at 105 and 115 MeV incident energy

I. Strojek[1], W. Czarnacki[1], W. Gawlikowicz[2], N. Keeley[1], M. Kisieliński[1,2], S. Kliczewski[3], A. Kordyasz[2], E. Koshchiy[4], M. Kowalczyk[2,5], E. Piasecki[1,2], A. Piórkowska[6], K. Rusek[1,2], R. Siudak[3], A. Staudt[6], A. Trzcińska[2]

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According to the cluster model, the ^{20}Ne nucleus consists of a hard core and one α-particle: ^{16}O + ^{4}He [1]. The binding energy of the system is relatively small. It is not surprising that the main product of the reaction of ^{20}Ne on ^{208}Pb is ^{16}O, in addition to the scattered ^{20}Ne projectile. The ^{16}O nucleus in this reaction is produced as a result of two processes: transfer of one α-particle from the neon projectile to the lead target or break-up of the ^{20}Ne into ^{16}O and ^{4}He. Since these are both direct reactions, the energy of the ^{16}O should be similar to the beam energy and its angular distribution will have a marked maximum in the vicinity of the grazing angle.

Apart from ^{16}O many other isotopes should be detected, which are the products of the transfer of one or more nucleons to or from the projectile. The study of transfer from neon is a very useful tool for studying the structure of the isotope.

Confirmation of these predictions was seen during an experiment performed in March 2009 at the Heavy Ion Laboratory in Warsaw, Poland. To detect and identify charged particles — products of the reaction — the multi-purpose scattering chamber ICARE was used with a set of gas telescopes [2]. The angular distributions for transfer reactions for oxygen and carbon are shown in Figures 1 and 2. The mass resolution was not enough to separate particular isotopes.

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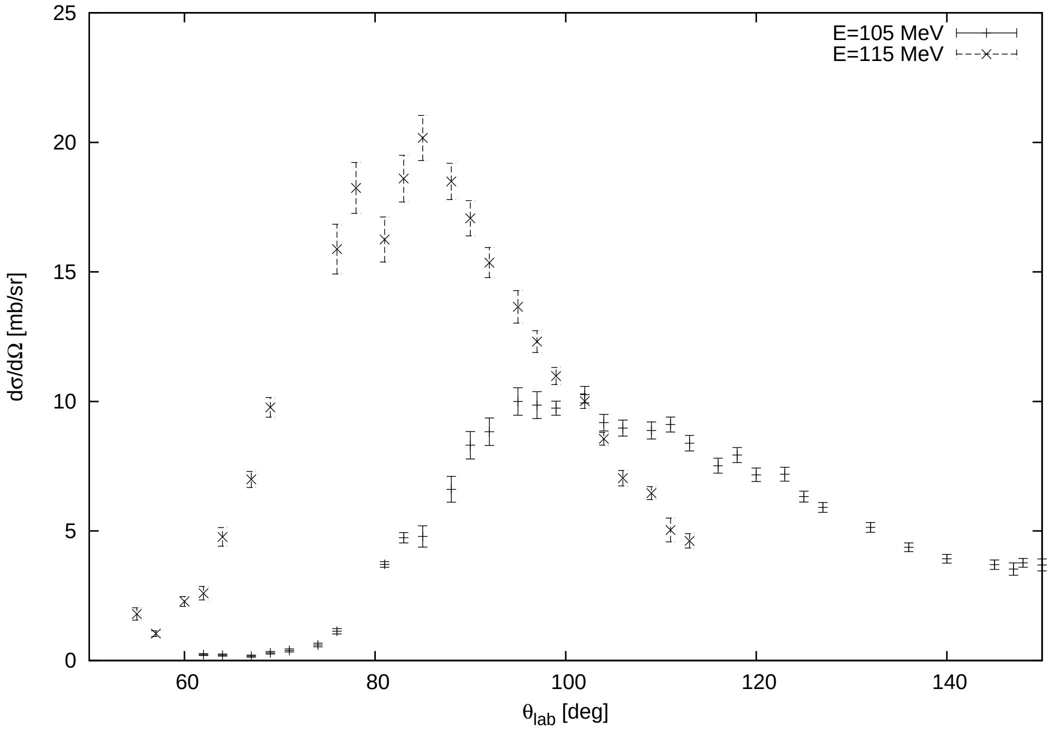

Figure 1: Differential cross section for Z=8 isotopes

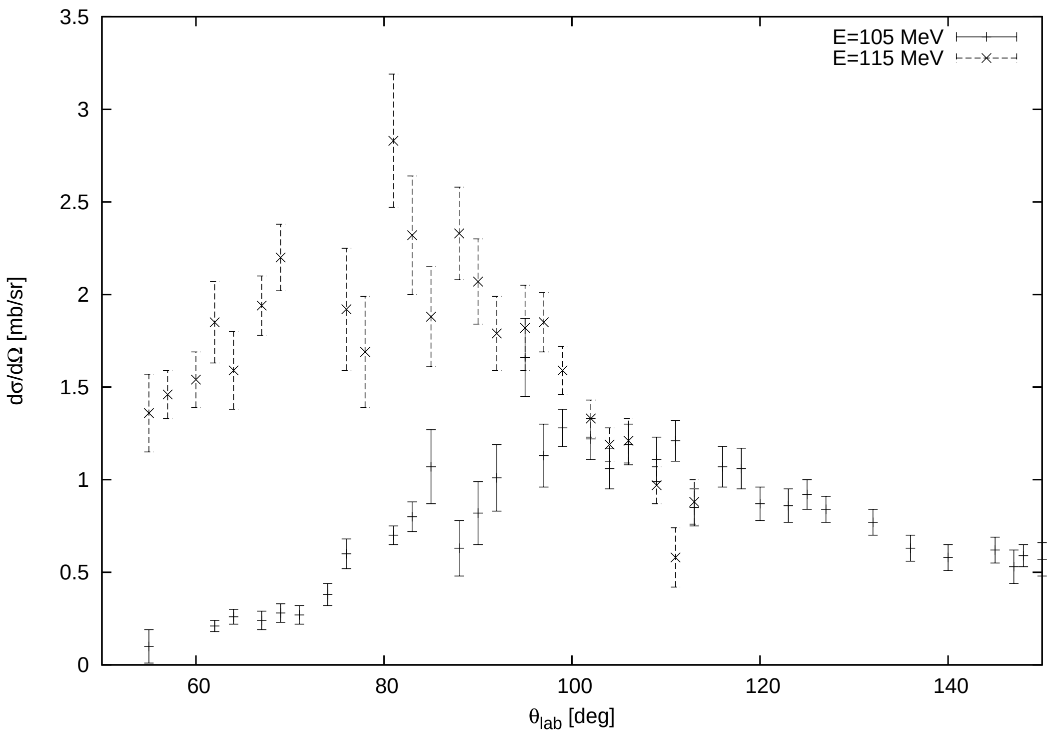

Figure 2: Differential cross section for Z=6 isotopes

B.3 Shape evolution in ^{100}Mo studied via Coulomb excitation — comparison with the GBH model predictions

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Among the stable even-even nuclei it happens very rarely that the excited state of spin and parity equal 0^+ lies very close in energy to the first excited 2^+ state. Such an unusual structure can be a first experimental indication of shape coexistence phenomenon and cannot be easily interpreted. The heaviest stable ^{100}Mo isotope belongs to this category. This report presents results concerning quadrupole shape evolution in this nucleus in terms of the shape coexistence phenomenon occurrence in the A$\sim$100 region of nuclear chart.

The Coulomb excitation experiment of ^{100}Mo was performed at HIL in December 2007 using the ^{32}S beam [1]. A standard analysis of the γ-ray spectra collected in coincidence with charged particles was performed and transition intensities were determined. Finally a set of 26 electromagnetic matrix elements describing couplings between the low-spin states of ^{100}Mo was found by a global fit of calculated to measured (or previously known) observables: γ-ray yields, level lifetimes, branching ratios and mixing ratios. The fits and related error calculations were performed using the Coulomb Excitation code GOSIA [2].

Quadrupole deformation parameters of the ^{100}Mo isotope in its ground and excited 0^+ states were extracted from the experimentally obtained set of E2 matrix elements. The rotational invariants method was used for this purpose [3]. To determine the overall deformation parameter $\langle Q^2\rangle$, transitional E2 couplings between the 0^+ states and all observed excited 2^+ states are important. In order to extract the triaxiality parameter $\langle\cos(3\delta)\rangle$, a more precise experimental information is needed — quadrupole moments of all 2^+ states as well as relative signs of all E2 matrix elements coupling 0^+ and 2^+ states. A more detailed description of this procedure and its application to the ^{100}Mo case can be found in Ref. [4].

Figure 1 shows the experimentally obtained quadrupole deformation parameters: $\langle Q^2\rangle$ and $\langle\cos(3\delta)\rangle$ for ^{100}Mo in the ground and excited 0^+ states compared to the theoretically calculated ones. The calculations were performed using the general Bohr Hamiltonian model GBH [5] with two variants of the Skyrme effective interaction: SIII and SLy4 [6].

The experimentally observed shapes of the ^{100}Mo isotope in its low-lying 0^+ states are qualitatively reproduced by the theoretical calculations. The overall deformation of the 0^+_1 state is lower compared to the one extracted for the 0^+_2 state. Both the theoretical and experimental results indicate the coexistence of the triaxial ground state and the prolate excited 0^+ state in ^{100}Mo. It is worth noticing that the results of the GBH calculations with the SLy4 variant of Skyrme interaction are in a better agreement with experimentally obtained overall quadrupole deformation parameters. This confirms the suggestion of Ref. [6] that the experimental Coulomb Excitation study of collective properties may provide an additional criterion when choosing the optimal parametrisation of the effective nucleon-nucleon interaction.

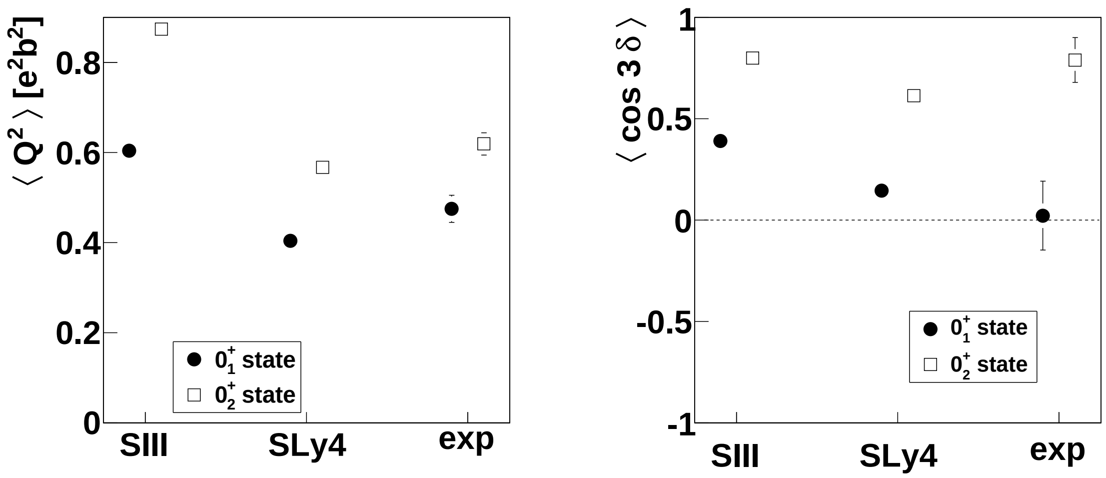

Figure 1: Experimental and theoretical expectation values of Q^2 (quadrupole overall deformation parameter) and $\cos(3\delta)$ (quadrupole asymmetry parameter) for the two first 0^+ states in ^{100}Mo; $\langle\cos(3\delta)\rangle$=1 corresponds to the prolate shape, $\langle\cos(3\delta)\rangle$=-1 – oblate shape, $\langle\cos(3\delta)\rangle$=0 – maximum triaxiality.

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B.4 Determination of the intrinsic quadrupole moments of the first two 2^+ states in ^{94}Zr using Coulomb excitation

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The A≈100 mass-region of nuclei is known to exhibit features of configuration coexistence in their low-lying level schemes. Furthermore,with increasing neutron number, the isotopic chains undergo a quantum phase transition from spherical vibrators to deformed nuclei. The configuration coexistence in the Z=40 nucleus ^{94}Zr has recently been confirmed in various experiments with different probes. Lifetimes, spins, g-factors and branching ratios of low-lying excitations and multipole-mixing ratios of connecting transitions have been determined with a very high accuracy (see Fig. 1) [1–4].

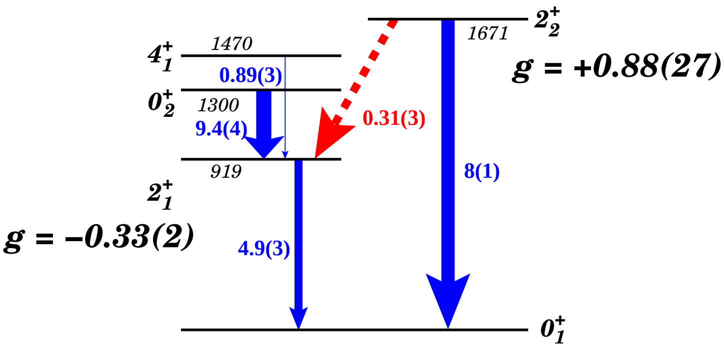

Figure 1: Available experimental information of ^{94}Zr previous to our experiment. The reduced transition probabilities (E2: solid line, M1: dashed) are given next to the arrows indicating the transitions.

The ^{94}Zr nucleus has the unique feature that the transition from the second excited 2_2^+ state to the ground state is stronger than the transition of first excited 2_1^+ state to the ground state. Measurements of the g-factors indicate a neutron dominance in the wave function of the first excited 2_1^+ state and a proton dominance in the wave function of the second excited 2^+ state. These experimental findings confirm the predicted configuration coexistence (see e.g. [5, 6]) in the proximity of the Z=40 sub-shell. Hereby, on the proton side a normal shell configuration with the $p_{1/2}$, $f_{5/2}$, and $p_{3/2}$ sub-shells filled and the $g_{9/2}$ sub-shell empty and an 2p-2h intruder configuration for which two protons are lifted into the $g_{9/2}$ sub-shell coexist at low excitation energies. However, the strong M1 transition connecting the 2^+ states also qualifies the second 2^+ state as a mixed-symmetry excitation [7].

In order to test these two pictures, we intend to measure the degree of quadrupole deformation of the first two excited 2^+ states by measuring the $Q_i \propto |\langle J_i|E2|J_i\rangle|^2$ (i=1,2) intrinsic quadrupole moments. By now, it is well established that a combination of precise lifetime information and the reorientation effect, displayed in Coulomb-excitation cross sections, yields this information [8]. Therefore, we initiated an experimental program at HIL to Coulomb excite ^{94}Zr using ^{40}Ar beams. In a first test experiment performed in February/March 2010 exploiting the Warsaw Coulomb excitation scattering chamber and the EAGLE HPGe-detector setup we were able to excite the first 2^+ state, and in a second order process, to populate the first excited 0^+ state via the first 2^+. However, the low-mass and subsequent low-Coulomb barrier of the ^{20}Ne projectiles limited our beam energies to ≈50 MeV, which does not guarantee a sufficient population of the second 2^+ state. The higher mass and nuclear charge of ^{40}Ar will allow to overcome these obstacles. Furthermore, the ^{94}Zr targets, used in the test, did not meet the quality standards needed for a quantitative analysis of a Coulomb excitation experiment. They will be replaced with targets of well defined thickness.

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B.5 Elastic scattering of ^{20}Ne+^{28}Si at 55 MeV

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A preliminary study of the system ^{20}Ne+ ^{28}Si was performed at 55 MeV via an elastic scattering angular distribution measurement. Data at several forward and two backward angles were collected and will be discussed in terms of coupled channel calculations.

Introduction

In the last decade a lot of experimental work has been devoted to the optical potential via heavy ion elastic scattering. Weakly bound projectiles, either stable or radioactive, have been used and the phenomenon of the potential threshold anomaly with consequences on the reaction mechanisms and coupling mechanisms has been sought. In this context, we have completed the study of the systems ^{6,7}Li+^{28}Si [1] at near barrier energies. To evaluate the "effect" of the projectile on the deduced potential behaviour and the involved reaction mechanisms our intention is to seek for data with stable projectiles. In the existing data on ^{12}C+^{28}Si and ^{16}O+^{28}Si another type of anomaly had been observed: unusually high cross sections in the back angle region of oscillatory nature partly attributed to the projectile and target clustering structure (see e.g. [2]). This observation makes the analysis of such data appealing, since in order to incorporate them in a phenomenological or a microscopic potential and isolate the potential threshold anomaly, it requires special tools. In this respect, we plan a series of measurements on ^{20}Ne+ ^{28}Si in a wide angular and energy range from 1 to 2.5 times the Coulomb barrier (E_{lab}(C.b).=36.2 MeV) In this direction, a preliminary run, to be described in this short report, concerns the elastic scattering study at 55 MeV, an intermediate energy of our future plans. Our data will be interpreted in a coupled channel scheme.

Experimental details and theoretical analysis

A ^{20}Ne beam with an intensity of a few electrical nA, delivered from the Warsaw Cyclotron, bombarded a 130 μg/cm^2 ^{28}Si target tilted by 45° degree to the beam direction, produced at LNS-Italy. Three telescopes and a single silicon detector positioned at the distance of 9 cm from the target at the two platforms of the ICARE target chamber, were used to collect the elastically scattered neon nuclei, well discriminated from other reaction products via the conventional ΔE-E technique. One platform was rotated in such a way as to obtain an angular distribution between θ_{lab}=20° to 55° while the second platform was kept fixed and the two telescopes were positioned at θ_{lab}=70° and θ_{lab}=90°. Two single silicon detectors were positioned at fixed angles of ± 20°, at the distance 19cm from the target, for normalisation purposes. Experimental results of an eight hours run are presented in Figure 1. The results are compared with the coupled channel calculations performed with the code Fresco. The central potential was taken in the standard form, $V = (1+0.5i)V_{DF}$,

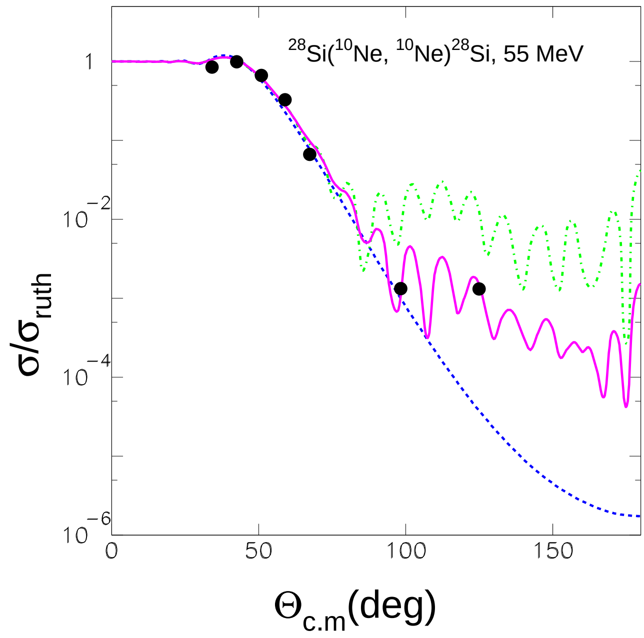

Figure 1: Elastic scattering data for ^{20}Ne+^{28}Si at bombarding energy of 55 MeV are compared with coupled channel calculations. Results without coupling are denoted with the dashed curve while results with coupling with the dot-dashed and solid curves (spectroscopic factor equal to 1 and to 0.5, respectively).

where V_{DF} is a double folded potential. The calculations included couplings to the 2^+ excited states in ^{20}Ne and ^{28}Si with the assumption to be conventional rotational states and also elastic transfer of a ^{8}Be cluster between all the possible combinations of states: $^{20}\mathrm{Ne}(0^+) + {}^{28}\mathrm{Si}(0^+)$,$^{20}\mathrm{Ne}(2^+) + {}^{28}\mathrm{Si}(0^+)$, $^{20}\mathrm{Ne}(0^+) + {}^{28}\mathrm{Si}(2^+)$,$^{20}\mathrm{Ne}(2^+) + {}^{28}\mathrm{Si}(2^+)$. In the first calculation the spectroscopic factor for $^{28}\mathrm{Si} = {}^{20}\mathrm{Ne} + {}^{8}\mathrm{Be}$ was taken as 1.0 and in the second as 0.5. Results without these couplings and with the couplings are compared in Figure 1 with the data.

Conclusions

From the comparison of the data with the theory it is obvious that at backward angles the anomalous increase of the cross sections persists even with a heavier projectile like ^{20}Ne. This can be described in a first approximation by the elastic transfer of a ^{8}Be from the target to the projectile. More detailed results at several energies and many more experimental data at backward angles are necessary to fully interpret this backscattering anomaly and probe additionally the threshold anomaly.

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B.6 Scattering and reactions of light nuclei

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A series of experiments with ^{18}O beams was performed in order to study the interactions of oxygen isotopes with lithium and carbon targets. The following processes were studied:

- ^{18}O + ^{14}C at 105 MeV, elastic and inelastic scattering leading to excitation of the projectile to 3.555 MeV, 3.920 MeV and 4.456 MeV states,
- ^{18}O + ^{13}C at 105 MeV, el. and inel. scattering leading to 1.982 MeV, 3.555 MeV, 3.921 MeV states in ^{18}O and 3.088 MeV, 3.684 MeV and 3.854 MeV states in ^{13}C,
- ^{7}Li(^{18}O, ^{16}N)^{9}Be transfer reaction at 114 MeV leading to the low lying states in the exit channel,
- ^{7}Li(^{18}O,^{17}N)^{8}Be transfer reaction at 114 MeV leading to a few states in ^{17}N.

These data sets as well as the data obtained previously with ^{16}O beam were analysed in the frame of Coupled Reaction Channel method (CRC). Information on the optical model potential parameters as well as on the reaction mechanism and spectroscopic factors was obtained [1–3].

An example of experimental data as well as theoretical calculations is presented in Fig. 1. The data were well reproduced assuming one proton transfer process. The excited states of ^{16}N at 1.850 MeV and 1.907 MeV could not be resolved experimentally and the solid curve shown in the figure consists of the two calculations, one for each excited state. Spectroscopic factors found from the comparison of the calculations with the data are close to the ones predicted by the translation-invariant shell model [4].

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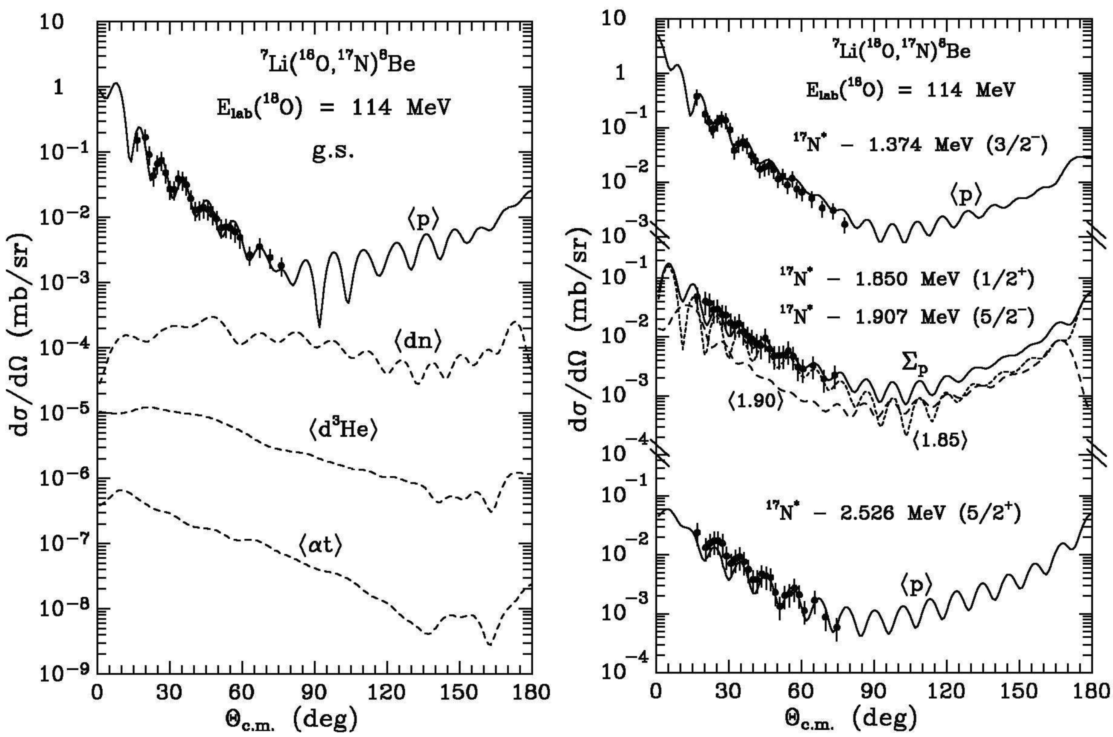

Figure 1: Angular distributions of the ^{7}Li(^{18}O,^{17}N)^{8}Be reaction leading to the different states in ^{17}N. The curves show results of CRC calculations (one-p roton transfer)

B.7 Silicon/liquid 5% HF junction

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Uniform resistance of silicon wafers is essential for proper working of silicon detectors. It is of special importance for the Pulse Shape Discrimination technique, where a single detector signal is used for charge and mass identification.

To obtain uniform silicon wafers, a non-destructive procedure to determine silicon wafer resistivity distribution is required. We proposed a C-V (Capacitance-Voltage) method [1] using a mercury drop gravitationally pressed to the tested silicon surface. Unfortunately, this technique resulted in contamination of silicon wafers.

Another option, which is currently being investigated, is to use a 5% water solution of the hydrofluoric acid (HF) to create a silicon/liquid junction that could be used for a non-contaminating determination of the silicon wafer resistivity distribution by the C - V method.

Semiconductor/liquid junctions are considered to be very efficient solar cells [2–5]. Creation of a silicon/liquid 5% HF junction was accidentally observed during thinning of the n^+-n silicon structures necessary to produce 7.3 silicon epitaxial membrane for thin strip detectors [6] using the anodic dissolution electrolyte jet equipment presented in Fig. 1.

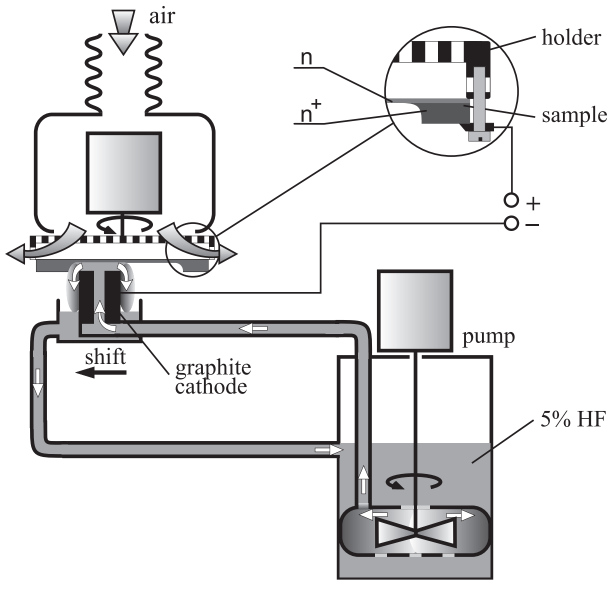

Figure 1: Electrolyte jet technique device used for thinning by anodic dissolution the large-area n^+–n oxidated silicon epitaxial wafers. After attaching an opposite voltage, the reverse current of the silicon/liquid 5% HF junction was observed.

The voltage-current characteristics and the open circuit voltages of silicon/liquid 5% HF junctions observed for various types of silicon wafers are presented in Fig. 2.

The voltage-current characteristics of the tested silicon/liquid 5% HF junctions was comparable to the one of Schottky semiconductor/metals junctions. In addition, the junctions show an excellent photo-effect.

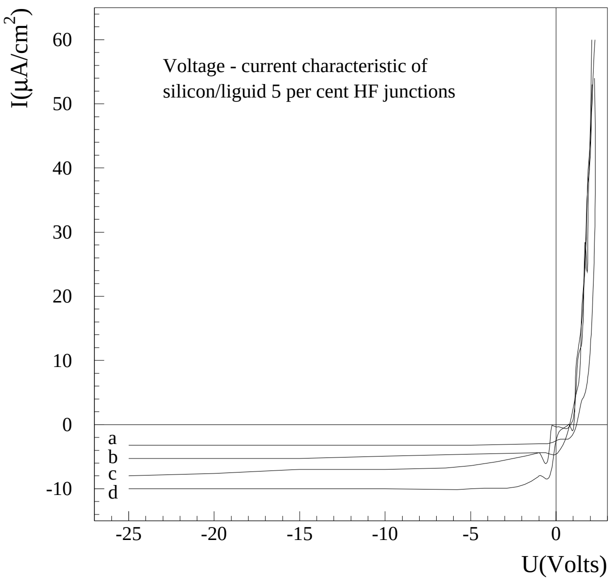

Figure 2: Voltage-current characteristics of silicon/liquid 5% HF junctions. (a) High resistivity silicon. Float zone. Tewa. (b) High resistivity silicon. Float zone. Topsil. Open circuit voltage 0.83 V. (c) High resistivity silicon epitaxial n^+-n. ITME. Open circuit voltage 0.63 V. (d) High resistivity silicon epitaxial n^+-n. ITME. Open circuit voltage 0.68 V. All voltages were measured with light illumination of junctions.

Since the fluoric acid is used for washing and cleaning of silicon materials, creating such a junction brings no risk of contaminating the tested silicon surface. In consequence, silicon/liquid 5% HF junction should be the best for C - V measurements of silicon wafers.

We would like to thank very much Magda Zielińska, Agnieszka Trzcińska, Krzysztof Rusek and Ludwik Pieńkowski for fruitful discussions and comments.

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B.8 Test of a four inch, 7.3 μm thick strip detector with the ^{252}Cf source

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We have elaborated a new technology of large area, thin silicon strip detectors, for the identification of super-heavy elements using a silicon vertex detector [1]. A photograph shown in Fig. 1 presents a four inch silicon epitaxial n^+-n structure with a thin 7.3 μm epitaxial membrane, transparent for visible light with detector strips created.

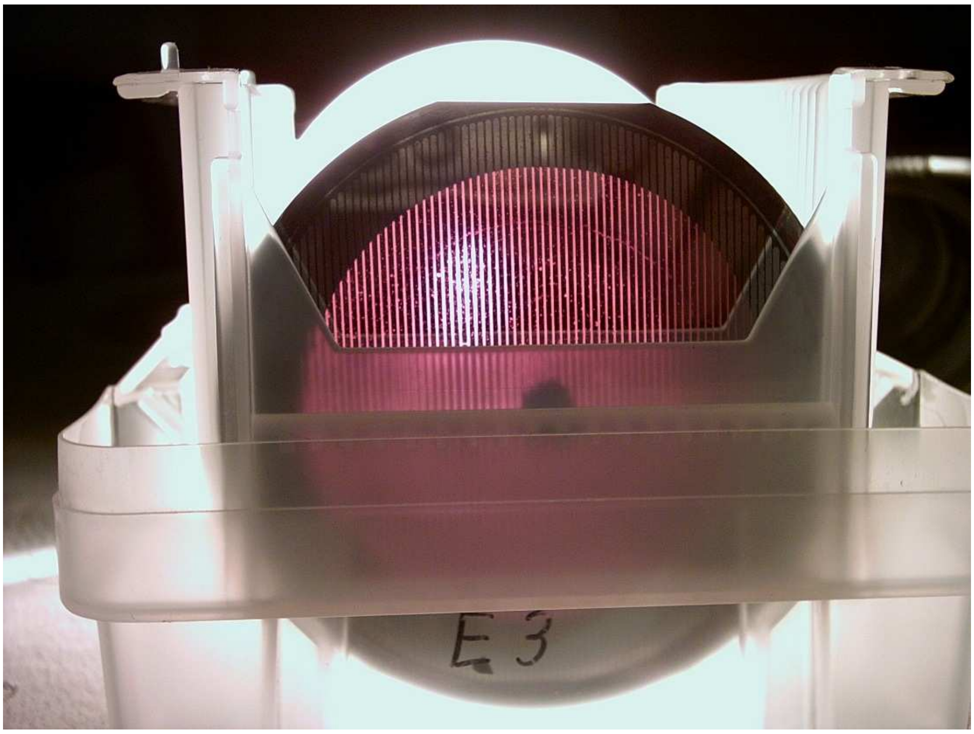

Figure 1: Four inch wafer with 7.3 μm thin silicon membrane supported by a thick 400 μm silicon n^+ substrate ring. The detector strips are visible in light illuminating the wafer from the back side.

A E-ΔE telescope was built using the strip ΔE detector shown in Fig. 1 and a PIN diode as an E detector. A narrow collimator was placed in front of the ΔE detector, so that only one strip could be reached by the incoming particles. The telescope was irradiated in vacuum by fission fragments and α particles from a ^{252}Cf source. The results of measurements are presented in Fig. 2.

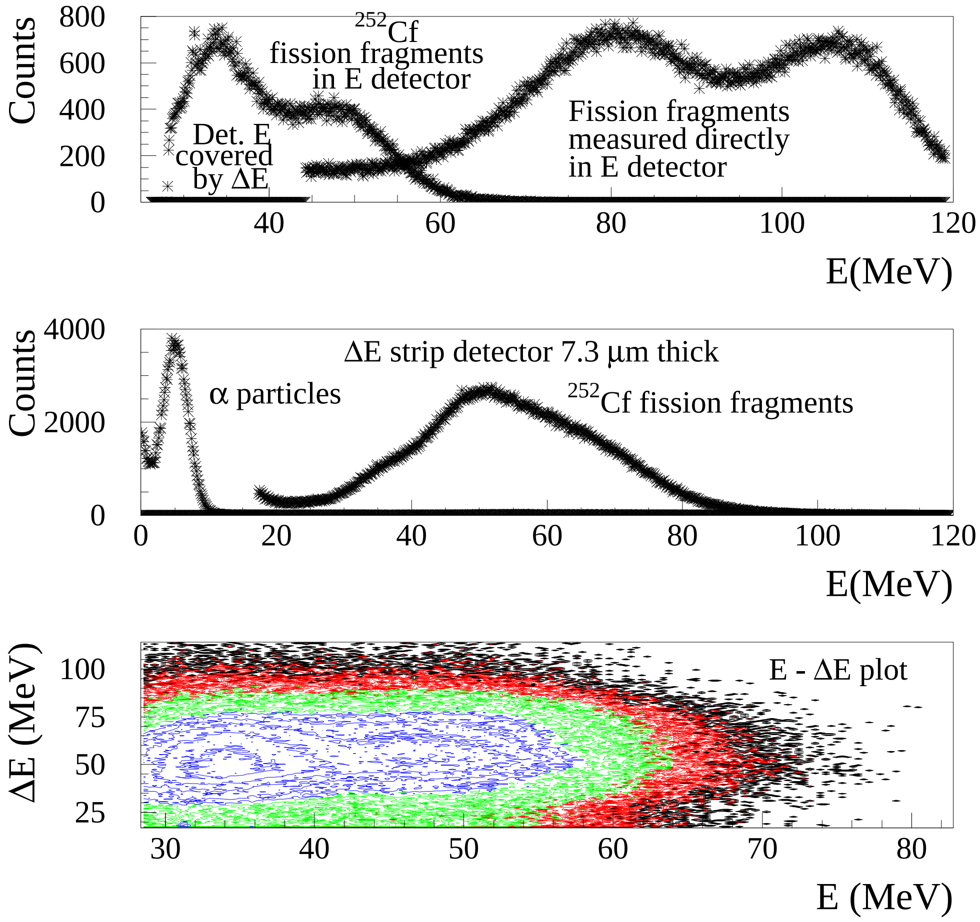

Figure 2: Upper plot: fission fragments directly measured by the PIN diode E detector (the right spectrum). After covering the PIN diode by 7.3 μm strip detector the energy of the fission fragments decreased (left spectrum). Middle figure: fission fragments (the central spectrum) and 11.2 MeV α particles from ^{252}Cf (left spectrum), measured by the 7.3 μm strip ΔE detector. The estimated energy resolution (FWHM) for α particles is about 0.42 MeV. Lower figure: an E-ΔE plot measured by the E-ΔE telescope. The two visible peaks, at about 34 and 46 MeV, are created by heavy and light fission fragments, respectively.

Acknowledgements

We would like to thank very much Magda Zielińska, Agnieszka Trzcińska, Krzysztof Rusek and Ludwik Pieńkowski for fruitful discussions and comments.

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B.9 Thin nickel targets for studies of the fusion-barrier height

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Investigation of the distribution of the fusion-barrier height performed with $^{20}Ne^{+9}$ ions provided by Warsaw Cyclotron required the following targets of nickel isotopes: ^{58}Ni, ^{60}Ni and ^{61}Ni [1]. The targets should be 80–100 $\mu g/cm^2$ thick with an active target area of 15 mm in diameter, most preferably self-supporting. Preparation of such thin self-supporting Ni targets is quite difficult. The foils of the suitable thickness can be prepared by evaporation, however, nickel foils of such thickness have a strong tendency to roll into tubes when self-supporting. This makes the mounting of the foils on the frames very difficult.

For earlier preliminary measurements targets were prepared at GSI Darmstadt, by e-gun and sputtering evaporation of Ni isotopes on Cu backing. To obtain self supporting Ni foils the Cu backing was removed by etching [2]. Further experiments required new sets of targets and their preparation was performed at Target Laboratory of Physics Department of Jyväskylä University. At first approach targets were made by sputtering technique using home made sputtering device with a sputter voltage of 10 kV and Ar ions as sputtering projectiles.

The foils produced by the procedure described in Ref. [2] were rolling into tubes after being released from the Cu backing (Fig. 1), what made mounting them on the frames impossible. The foils fixed to the frame before Cu etching were not stress free and cracked during the floating process or during drying step (Fig. 2).

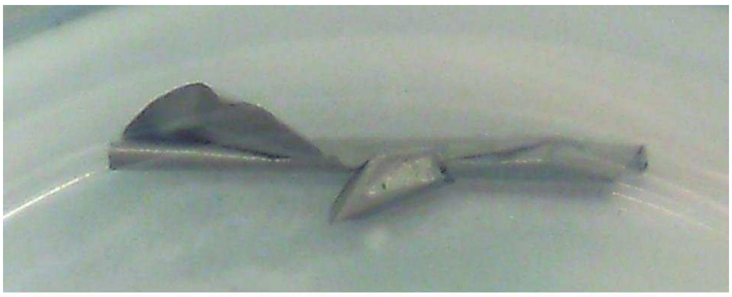

Figure 1: Ni foil made by sputtering on the Cu backing after etching the backing.

As required targets could be as well made on a thin backing, an attempt was made to deposit the nickel layers on a thin C foil. Unfortunately it was not successful, either. The C foil did not withstand bombardment by the sputtered Ni, or the stress building up inside the foil during the Ni deposition was too high.

Finally targets for the second part of the experiment were produced by deposition of the sputtered nickel on about 35 $\mu g/cm^2$ thick polyimide foil (PIF) produced in air or in argon atmosphere [3]. The sputtering voltage applied in this process was about 6.5 kV. The survival of the organic backing was a nice surprise after the failure with the Ni deposition on a thin carbon foil. According to the report from the end users, targets prepared this way survived a two hours long test bombardment by 50 MeV $^{20}Ne^{+9}$ ion beam of 30 nA intensity.

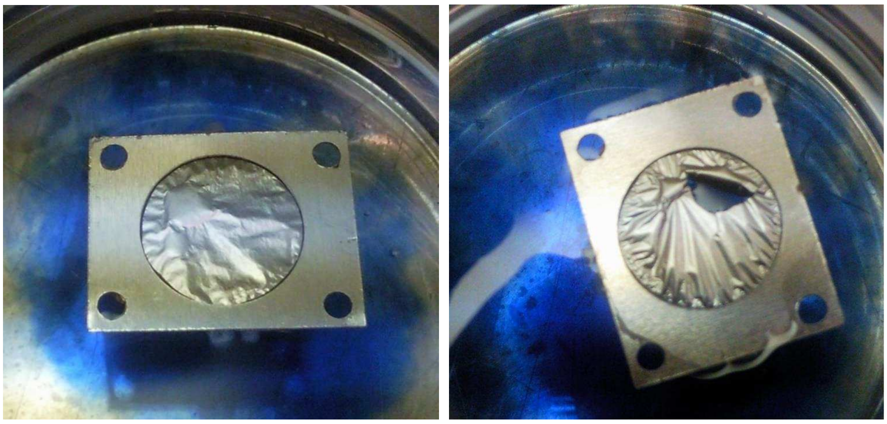

Figure 2: Ni foils prepared on the Cu backing during etching process

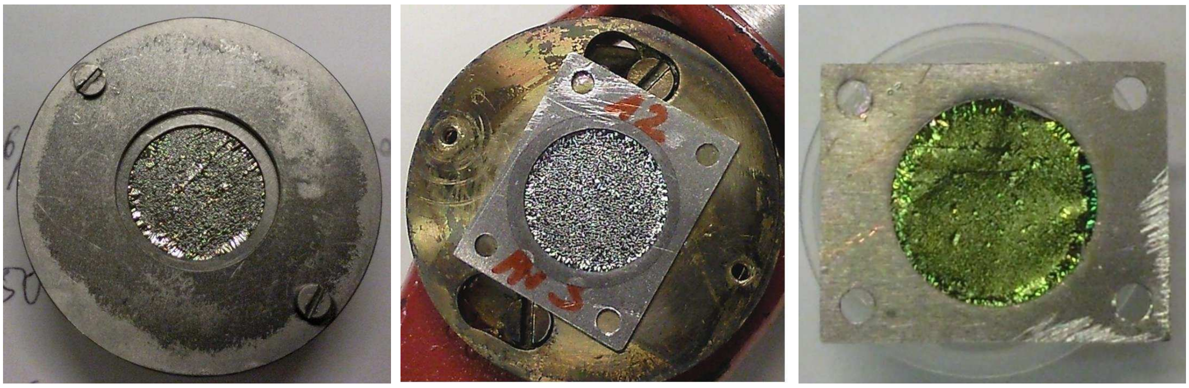

Figure 3: Left: the Ni target in the holder of the sputtering device (from the Ni side). Centre: the circle of the nickel (darker grey ring) on the frame guarantees the nickel contact with the frame to facilitate the heat transfer from the target material. Right: view of the target from the PIF side.

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B.10 First experimental validation of the NEDA simulations

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The conceptual design of the NEDA (NEutron Detector Array) project (see [1,2]) is at the final stage. This project aims at the construction of a new neutron detector system, with the primary objective to improve neutron multiplicity filtering in γ-ray spectroscopy fusion-evaporation experiments, especially when neutron emission is very rare. In order to validate the Geant4 simulations employed to evaluate properties of the new array, experimental tests of existing neutron detectors were performed in Uppsala and HIL, Warsaw. Two detectors were used (see Fig. 1): in Uppsala — a semi-hexagonal detector, originating from the NORDBALL neutron wall [3], and in Warsaw — a cylindrically shaped detector (diameter 153 mm, length 135 mm). The scintillation liquid filling both detectors was of BC501 type [4, 5]. In Uppsala data were processed with the analog electronics, including a NDE 202 pulse shape discrimination unit, and sent to a multi-channel analyser in a PC computer, while in Warsaw signals were probed by a CAEN DT5720 digitiser.

Figure 1: Neutron detectors used in the test measurements – the NORDBALL H10 detector evaluated in Uppsala (left) and a cylindrical detector tested in Warsaw (right).

The detectors were first irradiated with γ rays emitted by radioactive sources, and this enabled calibration of the light output signals in units of electron-equivalents (keVee). The γ-ray spectra collected with the hexagonal detector are shown in Fig. 2a–c. The broad peaks seen in these spectra are Compton edges of the respective γ rays — simulations indicate that the actual Compton edge energy value corresponds to 90% of the peak height, to the right of the peak's maximum. Basing on such γ-ray calibration points, the CFD threshold values could be converted to keVee units, resulting in 115 keVee and 50 keVee, in Uppsala and Warsaw, respectively. With the known calibration and threshold values, simulated spectra could be overlapped with the measured ones.

In the next step, ^{252}Cf γ-neutron sources were placed 51.0(5) cm and 5.0(2) cm in front of the detectors in Uppsala and Warsaw, respectively. Spectra of neutrons are shown in Fig. 2d. The neutrons in the Warsaw measurement were distinguished from γ rays using the charge comparison method [6]. The total neutron detection efficiency of the two

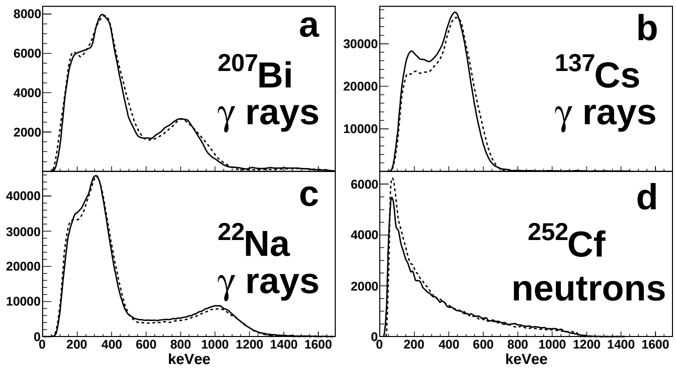

Figure 2: Experimental (solid line) and simulated (dotted) spectra obtained with the NORDBALL detector for γ-ray sources ^{22}Na (a), ^{207}Bi (b) and ^{137}Cs (c); as well with the cylindrical detector for neutrons emitted by the ^{252}Cf source (d). Neutrons were distinguished from γ rays using the charge-comparison method.

detectors was calculated and compared to the simulations, giving: 2.0(3)‰ and 2.41(2)‰ (in Uppsala), 6.2(9)% and 6.40(2)% (in Warsaw), for the measurements and simulations, respectively.

The shape of the simulated γ-ray spectra agrees well with the measurements. The most notable difference is visible in the 100–400 keVee part of the ^{137}Cs distribution, in which more counts were measured than obtained in the simulations and this discrepancy is not understood. The absolute γ-ray efficiency of the detector is anyway rather well reproduced — we obtain efficiency to register the ^{137}Cs γ rays of 2.56(13)‰ and 2.849(9)‰ in the experiment and simulation, respectively.

In the low energy part of the neutron spectrum the simulations give more counts than the measurement. One possible reason of such a difference is that the neutron γ-ray discrimination works worse at low light, and thus some low light neutrons could be lost in the measurements. Also, this may indicate a problem with the threshold determination, due to for example possible non-linearity of the light collection at low light values. Note that the lowest γ-ray calibration point was at 341 keV (Compton edge of the 511 keV γ-ray of the ^{22}Na source), and the threshold value was obtained by the extrapolation. The threshold position significantly influences the neutron efficiency, as the neutron light distributions strongly peak at zero. It can also be seen that all the simulated spectra are slightly shifted towards higher light values with respect to the measurement. This effect could be corrected for by changing the linear calibration coefficient by about 4%.

Further tests of neutron detectors are in progress, concentrating on the comparison of the properties of two scintillators considered for NEDA, BC501A and BC537 [4, 5].

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B.11 Parallel determination of the objective function value based on a distributed application structure

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Motivation

Coulomb excitation is a well established method to study electromagnetic properties of nuclei, including their shapes in ground and excited states. During the analysis, experimental data (γ-ray intensities, lifetimes, branching ratios etc.) are compared to the respective calculated values assuming a set of electromagnetic matrix elements that describe the internal structure of the nucleus under study. Such calculations can be performed using for example the GOSIA code written by T. Czosnyka [1], which also provides a fitness measure in the form of the χ^2 function. The optimisation process aims at finding a set of parameters with the lowest χ^2 value. It is conducted in two ways: either with a gradient method implemented in GOSIA or with a genetic algorithm implemented in JACOB by D.A. Piętak [2]. JACOB cooperates with GOSIA as an external objective function and determines a set of electromagnetic matrix elements. Determination of the χ^2 value is CPU time consuming so for efficient calculations large computing power is needed. The genetic algorithm enables to parallelise the objective function determination in each generation, and this feature can be used to speed up the calculations by employing in parallel more than one computer.

Distributed architecture

A client-server model was suggested to parallelise the objective function determination. As shown in Figure 1, communication proceeds between three distinct applications: JACOB (generator of the set of parameters — points), Server (distributor) and Client (calculator of the χ^2 value). An important task was to design two communication protocols: between JACOB and Server and between Server and Client. It is possible to run several JACOB and Client applications concurrently on different computers and provide their communication with Server. A special structure for distributing points was implemented to avoid mixing of points from different JACOB applications.

Performance of the system was checked with the test χ^2 value generator based on the Schwefel F7 function [3] as well as with the GOSIA code. In both cases Server properly distributed points to the Client and received the calculated objective function value.

At present all applications are working under the control of the Windows operating system. Design of the Client applications also for other environments (in particular Linux) is possible and foreseen. The system can be also applied to different tasks, for example data base search.

This work was performed as a project for Bachelor degree in computer science at the Cardinal Stefan Wyszyński University in Warsaw.

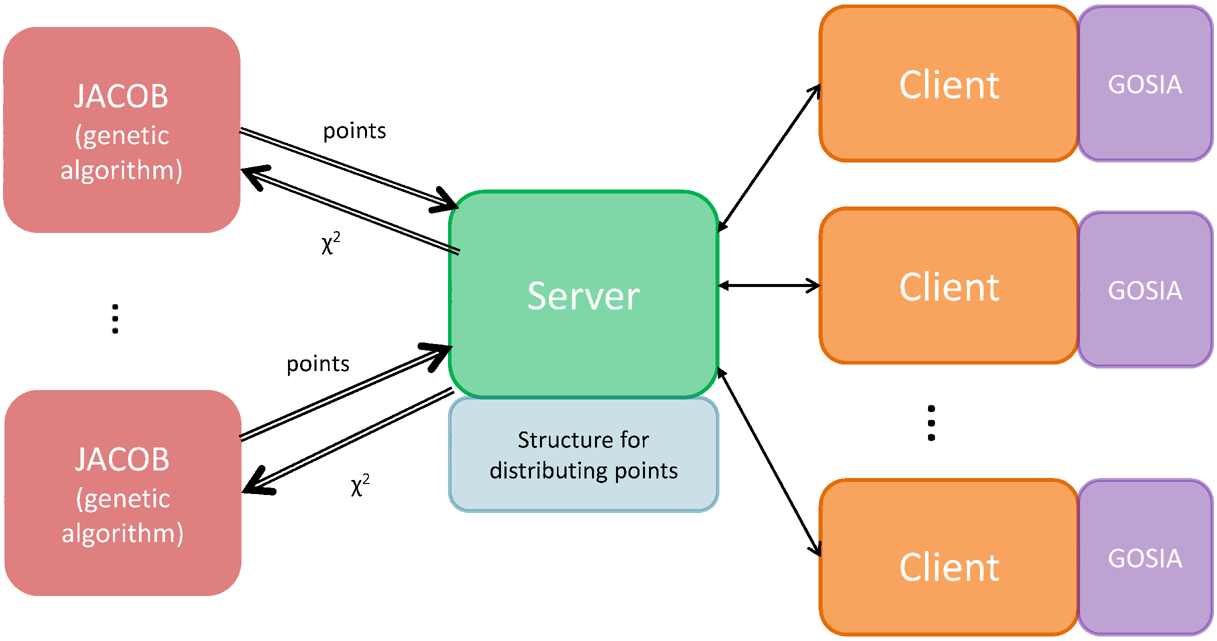

Figure 1: The distributed architecture of the system.

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B.12 Investigation of bystander responses in CHO-K1 cells irradiated by ^{12}C ions

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Understanding heavy ion radiation-induced bystander responses may provide useful insights into potential therapeutic approaches for the treatment of human cancers. The aim of this study was to investigate the bystander effects in Chinese hamster ovary cells (CHO-K1) exposed to 4 Gy of high LET ^{12}C ions (17 MeV), delivered by the cyclotron in the Heavy Ion Laboratory of the University of Warsaw.

Immediately after irradiation, cells were transferred into transwell culture insert dishes to enable a co-culture of irradiated and non-irradiated cells. For the clonogenic survival assay, bystander cells were seeded at 150 cells/well. Irradiated cells were plated on membrane of insert. For the micronucleus assay, bystander and directly irradiated cells were plated at 125×103 cells/insert/well. All data presented in our study are representative of four separate experiments in six repetitions.

<table>
<tr><th colspan="3">Micronucleus assay</th><th>MNC without MN</th><th>BNC with MN</th><th>CBPI</th><th>MN/1000 BNC</th></tr>
<tr><td colspan="3">Irradiated cells</td><td>0.63±0.05</td><td>0.068±0.011</td><td>1.452</td><td>294±75</td></tr>
<tr><td colspan="3">Bystander cells</td><td>0.18±0.03</td><td>0.010±0.004</td><td>1.860</td><td>13±6</td></tr>
<tr><td colspan="3">Control cells</td><td>0.13±0.03</td><td>0.013±0.004</td><td>1.917</td><td>16±6</td></tr>
<tr><th colspan="3">Clonogenic assay</th><th colspan="2">PE</th><th colspan="2">SF</th></tr>
<tr><td colspan="3">Irradiated cells</td><td colspan="2">0.73±0.05</td><td colspan="2">0.160±0.006</td></tr>
<tr><td rowspan="3">Bystander cells</td><td rowspan="3">density of irradiated cells in the insert:</td><td>100</td><td colspan="2">0.80±0.05</td><td colspan="2">1.04±0.04</td></tr>
<tr><td>5000</td><td colspan="2">0.85±0.05</td><td colspan="2">1.09±0.05</td></tr>
<tr><td>2500</td><td colspan="2">0.84±0.06</td><td colspan="2">1.05±0.06</td></tr>
</table>

Table 1: Effects of high LET ^{12}C ions irradiation on the frequency of micronuclei (MN) and clonogenic survival of directly and bystander CHO-K1 cells. [MNC-mononucleated cells; BNC-binucleated cells; CBPI-Cytokinesis-Block Proliferation Index; SF-Survival fraction; PE-plating efficiency]. At least 1000 cells were examined per point.

As presented in Table 1, we observed a significant increase in the frequency of MN in BNC as well as an elevated number of MNC and BNC with MN in directly irradiated cells, but not in bystander cells, as compared to control cells. These results were confirmed by the clonogenic survival results. The SF in directly irradiated cells was significantly reduced as compared to control cells. However, the SF in bystander cells was not affected, irrespectively of the density of irradiated cells.

To conclude, no bystander effect was found under the experimental conditions used in our study. However, a relationship between the number of BNC without MN and the SF in clonogenic assay was observed.

B.13 Determination of residual solvents in radiopharmaceuticals using static headspace gas chromatography

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PET (Positon Emission Tomography) is a new and dynamically developing method of metabolic imaging, which allows the diagnosis of early-stage tumors and its exact location. The method uses biologically active, β^+ labelled compounds and track their distribution in the patient body.

Molecular imaging with radiopharmaceuticals use short-lived isotopes (usually ^{18}F, ^{11}C, ^{13}N, ^{15}O). One of the most important aspects of working with radiopharmaceuticals is a short time (about 40 minutes) that can be spent on quality control and release procedures, thus the speed, simplicity and reliability of developed analytical methods are critical factors.

The aim of this study was to develop a rapid method for determination of residual organic solvents in the radiopharmaceuticals. The work was performed with the gas chromatography technique coupled with headspace sampler and FID (flame-ionisation) detector. Organic solvents (methanol, ethanol, acetonitrile, ethyl acetate and butane-1-ol) were determined in aqueous solutions. To optimise the procedure, the effect of temperature programs of headspace sampler and separation process was studied. The complete separation of solvents was achieved in less than 2 minutes. In real samples the ethanol content in ^{11}C-methionine and residual solvents in ^{18}FDG were determined with good accuracy and precision.

The validation process showed precision in range 6–9% (represented as RSD), determination limit (methanol 30 mg/L, ethanol 3 mg/L, and acetonitrile 4 mg/L, ethyl acetate 3 mg/L, butane-1-ol 3 mg/L) and the accuracy of the method (97–115%).

Part C

Experiments using outside facilities

C.1 Coulomb excitation of the presumably super-deformed band in ^{42}Ca. Preliminary results from the first AGATA Demonstrator experiment

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The Coulomb excitation experiment to study electromagnetic properties of low-lying states in ^{42}Ca with a focus on a presumably super-deformed band was performed at the Laboratori Nazionali di Legnaro in Italy in 2010. The γ-ray spectrometer AGATA Demonstrator coupled to the DANTE position sensitive charged particle detector array were employed. First results were presented at the Zakopane Conference on Nuclear Physics in 2010 [1].

Introduction

In the ^{42}Ca nucleus a rotational structure has been observed [2], which is similar to the previously identified super-deformed bands in several A $\approx$ 40 nuclei such as ^{40}Ca [3], ^{36,38}Ar [4–6]. Large transitional quadrupole moments in bands built on low-lying 0^+ states in ^{40}Ca suggested shape coexistence in this nucleus, which could be interpreted as an effect of multiparticle-multihole deformed excitations [7].

Lifetime measurements performed for the ^{42}Ca nucleus using the Doppler shift attenuation method [8] indicate a smaller deformation of the band built on the second 0^+ state (1837 keV) than in the case of the super-deformed band in ^{40}Ca. On the other hand, moments of inertia of these two bands were found to be very similar [2]. Another argument for the highly deformed character of this band was the observation of its preferential feeding by the decay of the low energy component of the highly split GDR in ^{46}Ti [9].

Coulomb excitation of ^{42}Ca

In order to resolve the existing ambiguities concerning the deformation of the presumably super-deformed band, a Coulomb excitation measurement has been performed to extract the B(E2) values in ^{42}Ca. The experiment took place in February 2010 at the Laboratori Nazionali di Legnaro. For this measurement, the γ-ray spectrometer AGATA Demonstrator [10] coupled to the charged particle detection set-up DANTE [11] was used for the first time.

A ^{42}Ca beam of 170 MeV energy bombarded a 1 mg/cm^2 target of ^{208}Pb. Gamma rays from Coulomb excited nuclei were measured in coincidence with back-scattered projectiles, detected by three position-sensitive heavy ion micro-channel plate detectors forming the DANTE array that covered θ range from 100° to 144°. The AGATA Demonstrator spectrometer, consisting of three triple germanium clusters, was used to measure γ-ray transitions in the energy range up to 3 MeV. Data acquisition of the AGATA array was fully digital, while MCP detectors signals were processed by analog electronics. The read-out of DANTE was synchronised and merged with the AGATA acquisition system using the AGAVA interface.

Transitions deexciting the highly deformed band were observed, as well as γ rays depopulating low-lying states in the yrast band. In both the ground state band and the highly deformed band it was possible to Coulomb excite levels of spin up to 4^+. Doppler correction was performed based on the information on particle scattering angle provided by MCP detectors. In Fig. 1 the total γ-ray spectrum in coincidence with one of the DANTE detectors is shown. In addition to the γ lines coming from known low energy states in ^{42}Ca, γ rays depopulating the Coulomb excited states of the lead target and the aluminium holder nuclei are visible. These lines are significantly broadened since the Doppler correction was performed for the ^{42}Ca scattered projectile.

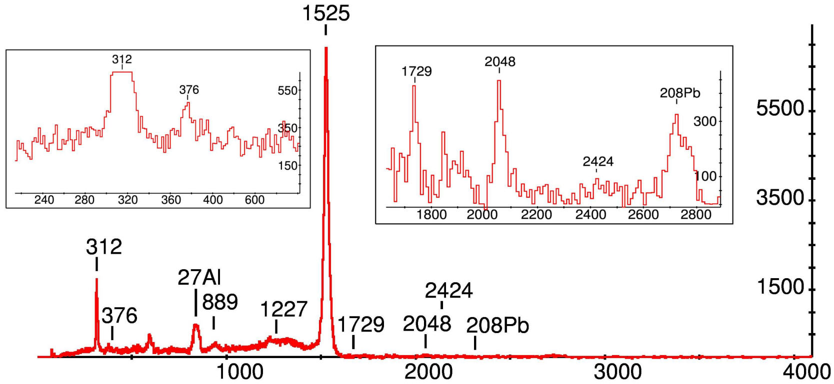

Figure 1: Doppler-corrected γ-ray spectrum observed in the ^{42}Ca + ^{208}Pb Coulomb excitation experiment. The insets present 376 keV and 2048 keV γ-ray transitions.

Unexpectedly, a very strong 2048 keV γ-ray transition is clearly visible. Its width indicates that this line comes from the ^{42}Ca scattered projectile. There are several options, which should be taken into consideration regarding the origin of such a γ line. The calculations of respective transition probabilities performed using the GOSIA code [12] exclude the attribution of the 2048 keV line to the known level scheme of ^{42}Ca.

Additionally a 376 keV γ-ray was observed in this experiment (see Fig. 1). Existence of such a γ line supports the scenario that both 376 and 2048 keV transitions are related to a new postulated 3^- or 2^+ state located at 2048 keV, populated in the Coulomb excitation process (Fig. 2).

Detailed discussion of all possible spin and parity assignments of the level which de-excites by the γ-ray transition of 2048 keV is presented in [1].

Summary

Coulomb excitation of low-lying levels in ^{42}Ca was observed up to 4^+ states in both the ground state band and the highly deformed band. A new strong gamma-ray transition at the energy of 2048 keV was identified in the spectrum. The most probable interpretation is that this line originates from a new state located at 2048 keV, populated in the Coulomb excitation process.

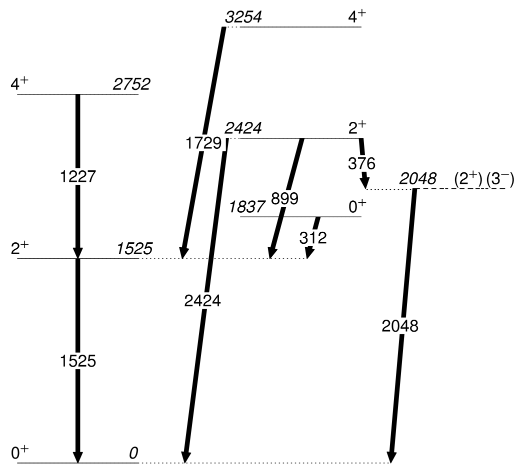

Figure 2: The level scheme of ^{42}Ca observed in the present experiment with the tentatively assigned 3^- or 2^+ state at the energy of 2048 keV.

Further analysis, which will provide information on electromagnetic properties of the highly deformed band by determination of B(E2) values, is in progress.

Special acknowledgement for support and help goes to all members of the AGATA Collaboration and the LNL Legnaro accelerator technical staff.

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C.2 Coulomb excitation of ^{182,184,186,188}Hg at REX-ISOLDE

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Almost three decades ago, isotope shift measurements [1] observed a sharp shape transition in the light mercury isotopes. Still, the phenomenon of shape coexistence in these heavy nuclei is not fully understood. In light even-mass mercury isotopes it is suggested that a weakly deformed oblate ground state band ($\beta_2 \approx$-0.15) coexists with a more deformed ($\beta_2 \approx$0.25) prolate band that is associated with proton pair excitations across the Z=82 shell [2, 3]. In spite of the large body of data supporting the coexistence of different shapes at low excitation energies in mercury isotopes, little is known about transitional and diagonal matrix elements of the excited states.

Coulomb excitation at safe energies allows the investigation of the transitions between low-lying states, revealing information on the mixing of different bands. Pure beams of ^{182,184,186,188}Hg were delivered by the ISOLDE-CERN radioactive beam facility to a stable Cd target (^{112}Cd or ^{114}Cd) placed in the middle of the MINIBALL gamma spectrometer to induce Coulomb excitation. The intensities at the target position were 4.9×10^3 pps (^{182}Hg), 1.0×10^5 pps (^{184}Hg), 2.5×10^5 pps (^{186}Hg) and 3.1×10^5 pps (^{188}Hg).

Observed de-excitation rates enable the transitional quadrupole matrix elements connecting different states to be extracted (see Fig. 1). Also the sign of the diagonal matrix element of the first excited 2^+ state, containing the information about the nuclear quadrupole deformation, could be determined experimentally. In addition to the decay of the first 2^+ state, transitions from the second 2^+_2, $4^+_{1,2}$ and 0^+_2 states have been observed. Coulomb excitation data analysis is being finalised.

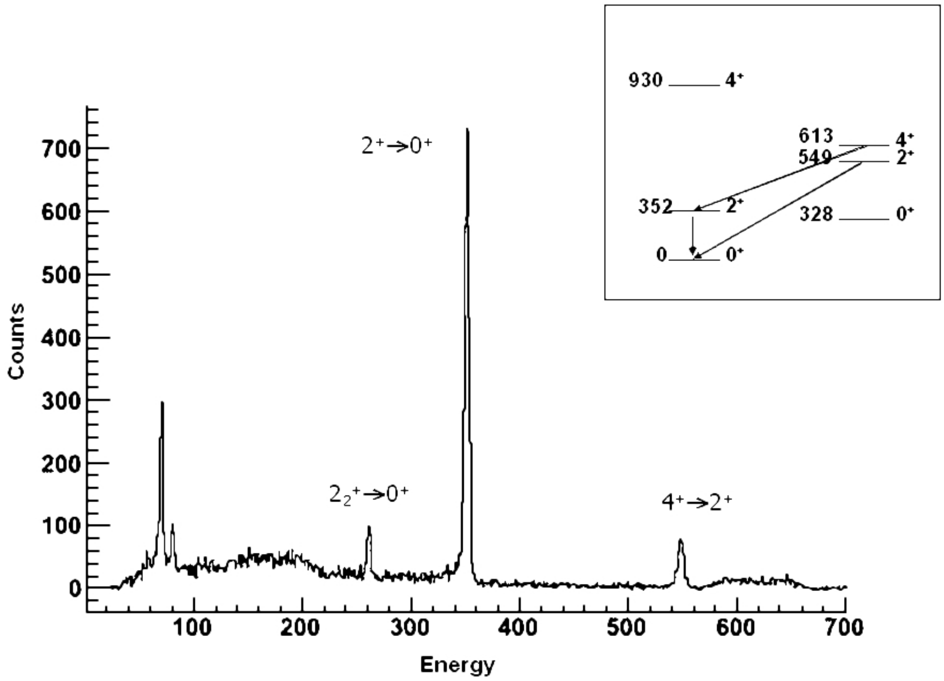

Figure 1: Total Doppler-corrected gamma-ray spectrum obtained for ^{182}Hg.

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C.3 Polarisability of ^{6}He from ^{6}He+^{208}Pb scattering at 22 MeV

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The effective interaction between the two scattering nuclei could be written as a sum of a standard energy independent optical potential and a complex term called dynamic polarisation potential (DPP) that is reproducing effects of real and virtual processes taking place during the scattering. DPP potential could be derived from the microscopic analysis of the scattering performed by means of coupled-channel calculations (CC). If the DPP is derived correctly, the simple optical model calculations with such effective interaction should reproduce the original CC calculations.

It was shown [1] that DPP's derived for weakly bound projectiles exhibit a universal radial dependence; their real parts (V_{DPP}) change from repulsive to attractive with the increased radius while the imaginary parts (W_{DPP}), close to zero or even emissive at the nuclear surface, are becoming absorptive at large distances. If the Coulomb dipole couplings dominate, the long range tail of the DPP should be well described by a classical dipole correction to the potential energy,

$$\Delta V = -\frac{1}{2}\alpha\frac{Z^2e^2}{R^4} \tag{1}$$

where the constant α is the electric dipole polarisability.

The ^{6}He + ^{208}Pb elastic scattering data at 22 MeV [2] were analysed by CC calculations with included couplings to the $\alpha + 2n$ continuum (Fig. 1) and DPP potential was derived from the calculations by means of trivially equivalent method. The radial dependence of DPP's real and imaginary components are plotted in Fig. 2 by the solid curves. The real component V_{DPP} represents effects of virtual couplings on elastic scattering (polarisability) while the imaginary component W_{DPP} is responsible for the removal of ^{6}He flux due to ^{6}He $\rightarrow \alpha + 2n$ breakup. The real component could be well fitted at large projectile-target separations by Eq. 1 with $\alpha = 1.4$ fm^3 (dashed curve). The imaginary component is of shorter range and could not be well fitted by Eq. 1. In order to convince the reader we plotted the dashed curve in Fig. 2 corresponding to $\alpha = 0.65$ fm^3.

In summary, we have demonstrated that for weakly bound ^{6}He the couplings with the α+$2n$ continuum are dominated by the dipole excitations and that the dipole polarisability parameter derived from ^{6}He + ^{208}Pb elastic scattering at 22 MeV is equal to 1.4 fm^3.

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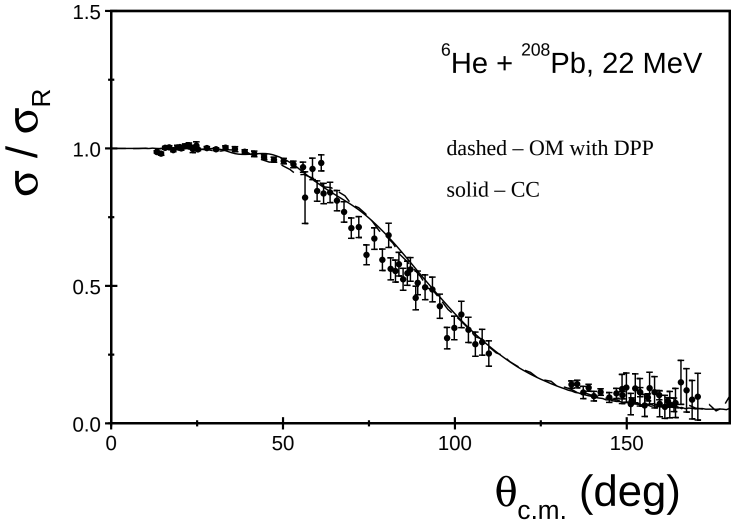

Figure 1: Analysis of elastic scattering data by means of CC calculations. OM calculations with the DPP derived from CC analysis give almost identical results. Experimental data from Ref [2].

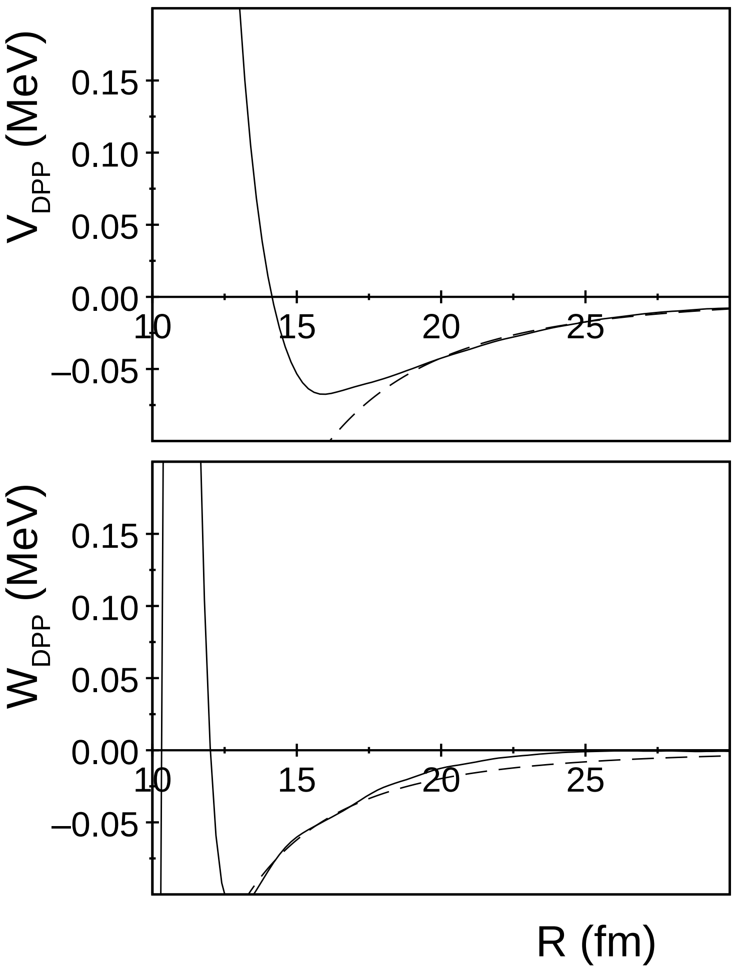

Figure 2: Dynamic polarisation potential for ^{6}He+^{208}Pb derived from CC analysis of elastic scattering data at 22 MeV (solid curves). The dashed curves show its approximation by classical Coulomb form [1] with $\alpha = 1.4$ fm^3 (V_{DPP}) and $\alpha = 0.65$ fm^3 (W_{DPP}).

C.4 Magnetic moment measurement of the I=9 isomeric state in ^{128}Cs

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6) *CSNSM, CNRS-IN2P3 and Université Paris-Sud, Orsay, France*

The yrast band of the ^{128}Cs nucleus built on the I=9 isomeric state has aroused both the theoretical and experimental interest for several years. The role of proton-neutron interaction together with triaxiality in signature inversion observed in the yrast band has been studied in Refs. [1, 2]. The postulate of the triaxial deformation together with experimental observation of another rotational band being similar to the yrast one [3] has put the chiral interpretation of the ^{128}Cs nucleus in favour. In the chiral scenario a characteristic electromagnetic behaviour of the two partner bands has been predicted in Ref. [4]. The DSA lifetime measurements of the rotational states belonging to the partner bands reported in Ref. [5] confirmed their chiral interpretation. Although the above-mentioned studies present a consistent interpretation of the ^{128}Cs structure, they are based on elementary assumption of the $\pi h_{11/2} \otimes \nu^{-1} h_{11/2}$ yrast I=9 band-head configuration that has not been confirmed experimentally as yet. The idea of the chiral symmetry breaking allowed to explain the existence of two nearly degenerated rotational bands. In some cases however another interpretation of such bands — based on the pseudo-symmetry — can be applied [6] where other particle configurations of the yrast band-head are involved. In this interpretation the heads of the two rotational bands would have a particle configurations of two close lying Nilsson levels — the pseudo-spin doublet [7].

The Time Dependent Perturbed Angular Distribution (TDPAD) method [8,9] was used to determine the g-factor of the yrast I=9 band-head. In the measurements performed at IPN Orsay the ^{128}Cs nucleus was produced in the ^{122}Sn(^{10}B,4n)^{128}Cs reaction at 55 MeV beam energy. The pulsed beam was provided by the Tandem accelerator with 1 ns pulses and 400 ns repetition period. The self supporting ^{122}Sn target, 22 mg/cm^2 thick, played simultaneously the role of a stopper for the recoils. The magnetic field of around 7 kGauss attainable at the electromagnet was magnified with help of the GAMIPE reaction chamber of LNL Legnaro laboratory, equipped with cone-shaped iron poles. The uniformity of the magnetic field and its value at the beam spot (of 1 mm^2 size) equal 21460 Gauss were measured before and after the experiment. According to the theoretically expected magnetic moment of the I=9 isomeric state, such magnetic field should give a spin precession period around 100 ns.

Two Low-Energy Photon Spectroscopic (LEPS) detectors of Laboratori Nazionali di Legnaro were placed at angles ±45° with respect to the beam axis. The excellent time resolution of the LEPS detectors vs. γ quanta energy is gained at the expense of registration efficiency of high-energy electromagnetic radiation. Therefore two other Ge spectrometers — standard HPGe detectors with a beryllium window and 25% relative efficiency — were placed at angles ±135° to increase the registration efficiency for high-energy gammas.

The I = 9 spin assignment for the yrast band-head (see Fig. 1) of ^{128}Cs has been proposed according to the argument of the excitation energy systematics [3, 10]. The same argument has been used for parity assignment. The even parity has been adopted in Ref. [3] basing on the results of the conversion coefficient measurement for ^{124}Cs [11].

By applying the time dependent perturbed angular correlation method the giromagnetic factor $g = 0.59(1)$ has been obtained. The magnetic moment is the only experimental quantity measured directly for the I=9 isomeric level. The detailed paper presenting the experiment together with theoretical evaluation is in preparation.

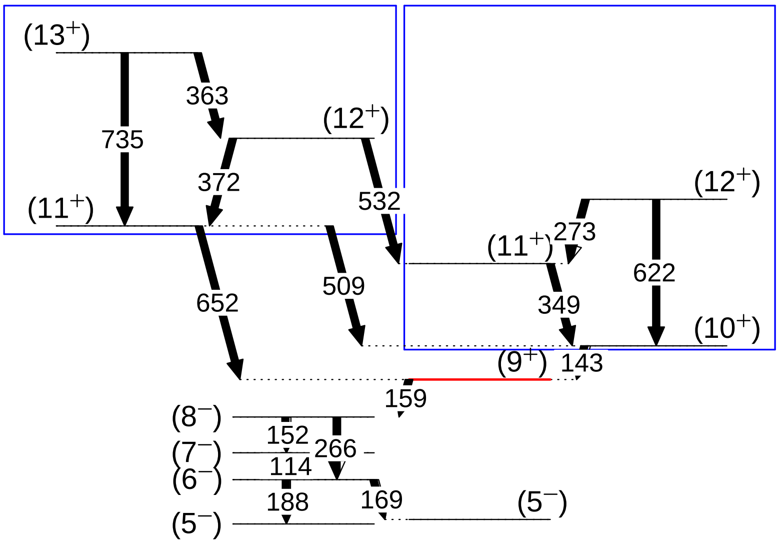

Figure 1: Partial level scheme of ^{128}Cs taken from Ref. [3]. The 50 ns isomeric state is indicated in red. The bottoms of the partner bands are shown in blue frames.

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C.5 Determination of antioxidant properties of tea infusions

A. Pękal[1,2], M. Biesaga[2], K. Pyrzyńska[2]

1) Heavy Ion Laboratory, University of Warsaw, Warszawa, Poland
2) Faculty of Chemistry, University of Warsaw, Warszawa, Poland

Tea infusions, consumed by two thirds of the world's population, are obtained from the leaves of one kind of a plant named Camellia sinensis. Tea leaves are primarily manufactured as green, black, or oolong, with black tea representing approximately 80% of tea products consumed. They differing in appearance, organoleptic taste, chemical content as well as flavour due to their respective fermentation process. In recent years, tea is extensively investigated mainly regarding its influence on human health [1]. Regular intake of tea is associated with an improved antioxidant status in vivo that may contribute to lowering the risk of coronary heart disease, atherosclerosis, reduced mutagenicity and inflammation [2].

Polphenolic compounds are known as good radical scavengers. Tea is a rich source of them. Antioxidant properties of water extracts of the commercial bagged teas were evaluated. To check antioxidant activity of tea infusion, total phenolic content by Folin-Ciocalteu (F-C) assay, cupric ion reducing capacity (CUPRAC) and DPPH radical method were used. The content of selected flavonoids and phenolic acids was also determined by high-performance liquid chromatography with tandem mass spectrometry in the negative electrospray ionisation mode.

In DPPH assay fruit teas showed slow antioxidant behaviour in comparison with black ones, but green teas were the best radical scavengers. Fig. 1 shows that antioxidant properties depending on the type of water used for brewing. For preparation of tea infusions three kinds of water were used: distilled water (pH 7.71), tap water from our laboratory (pH 8.09) and spring water (pH 8.72) from an underground source in Warsaw (Poland). The influence of the type of water was visible also in case of rest of all other tested teas, so we can suspect that it is related to the content of metal ions in infusions. Polyphenolic compounds can chelate metals and even react with them [3].

Infusions of green teas exhibit higher trolox equivalent antioxidant capacity (TEAC) values in CUPRAC method than black and fruit teas; after incubation with reagents at 50°C all TEAC values increased. Folin-Ciocalteu research research exhibit the same order of teas according to higher antioxidant properties. HPLC analysis showed high level of naringin and hesperidin in fruit tea infusion. Jung et al. [4] found that supplementation with hesperidin and naringin, both citrus bioflavonoids, significantly reduced blood glucose, while the bone and lipid benefits of hesperidin make it an attractive dietary agent for the management of the health of postmenopausal women [5]. Black tea infusion has high concentration of quercetin, rutin and phenolic acids in contrast to fruit teas. Green teas exhibit the highest level of catechins concentration, what makes it the best antioxidant from tested teas.

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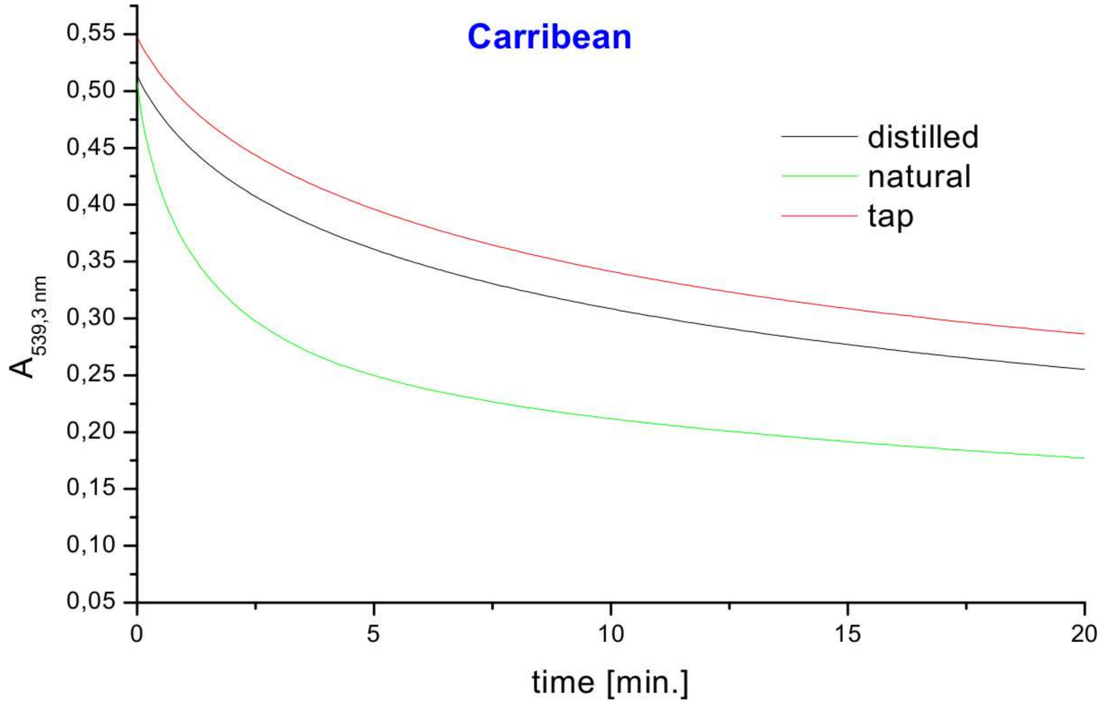

Figure 1: Kinetic of DPPH scavenging for chosen fruit tea brewed in different types of water.

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Part D

Appendices

D.1 Degrees and theses completed in 2010 or in progress

D.1.1 Professor nominations

Ernest Piasecki received the professor nomination from the President of the Republic of Poland on 3 March 2010

D.1.2 DSc theses of HIL staff members

Wojciech Gawlikowicz
Dynamical and statistical fragment production in heavy-ion collisions at intermediate energies
Thesis defended on 14 June 2010

D.1.3 PhD theses of students affiliated to HIL and of HIL staff members

Katarzyna Wrzosek-Lipska
Badanie struktury elektromagnetycznej niskospinowych stanów wzbudzonych jądra ^{100}Mo metodą wzbudzeń kulombowskich
Electromagnetic structure of low-spin excited states in ^{100}Mo studied using Coulomb excitation method
Supervisor: dr hab. L. Pieńkowski. Thesis defended with honours on 7 March 2011

Jan Mierzejewski
Mechanizm niekompletnej fuzji badany z wykorzystaniem EAGLE i SiBall
Mechanism of incomplete fusion studied with EAGLE and SiBall
Supervisor: prof. dr hab. T. Matulewicz. Expected completion time: 2012

Grzegorz Jaworski, Faculty of Physics, Warsaw University of Technology
Modelowanie wieloelementowych układów detekcyjnych w badaniach struktury egzotycznych jąder atomowych
Modeling of multidetector arrays in studies of exotic nuclei structure
Supervisor: prof. dr hab. J. Kownacki. Expected completion time: 2012

Katarzyna Hadyńska-Klęk
Badanie struktury kolektywnej w izotopach wapnia metodą wzbudzeń kulombowskich
Studies of collective structure in calcium isotopes using Coulomb excitation method
Supervisor: prof. dr hab. M. Kicińska-Habior. Expected completion time: 2012

Daniel Piętak, Institute of Radioelectronics, Warsaw University of Technology
Metoda oceny jakości wyników z eksperymentów wzbudzeń kulombowskich z wykorzystaniem algorytmu genetycznego
Evaluation method based on a genetic algorithm for results of Coulomb excitation experiments
Supervisor: prof. dr hab. J. Wojciechowski. Expected completion time: 2012

D.1.4 DSc theses based on experiments performed at HIL

Stanisław Kliczewski, The Henryk Niewodniczański Institute of Nuclear Physics PAN, Kraków, Poland,
Study of light and stable nuclei with heavy ion reactions
Thesis defended on 17 May 2010

D.1.5 PhD theses based on experiments performed at HIL

Volodymyr O. Romanyshyn, Institute for Nuclear Research, Ukrainian Academy of Sciences
Nuclear processes in the collision of the $^{7}Li + {}^{10}B$ ***nuclei***
Supervisor: prof. A.T. Rudchik. Thesis defended on 16 April 2010

Joanna Czub, Faculty of Physics, Świętokrzyska Academy
Biologiczne działanie promieniowania o wysokim LET
Biological effects of radiation with high LET value
Supervisor: prof. dr hab. J. Braziewicz. Expected completion time: 2011

Izabela Strojek, The Andrzej Sołtan Institute for Nuclear Studies, Świerk
Wpływ struktury jądra ^{20}Ne ***na reakcje z jego udziałem***
Influence of the ^{20}Ne *structure on reactions with this nucleus*
Supervisor: prof. dr hab. K. Rusek. Expected completion time: 2012

Urszula Kaźmierczak, Faculty of Physics, University of Warsaw
Supervisor: dr hab. Z. Szefliński. Expected completion time: 2014

Łukasz Janiak, University of Łódź
Supervisor: prof. dr hab. J. Andrzejewski. Expected completion time: 2014

Justyna Samorajczyk, University of Łódź
Supervisor: prof. dr hab. J. Andrzejewski. Expected completion time: 2014

D.1.6 MSc theses supervised by HIL staff members

Mikołaj Tarchalski, Faculty of Physics, Warsaw University of Technology
Korekcja rozkładu oporności właściwej płytek krzemowych metodą lokalnego neutronowego domieszkowania
Correction of resistivity of Si wafers using Selective Transmutation Doping
Supervisor: dr hab. A. Kordyasz. Thesis defended in 2010

Grzegorz Mentrak, Faculty of Physics, Warsaw University of Technology
Opracowanie układu cyfrowo-analogowego sterowania zasilaczami prądu stałego do magnesów odchylających w Warszawskim Cyklotronie
A digital/analog control system for DC power supplies for bending magnets of the Warsaw Cyclotron
Supervisor: dr. J. Choiński. Expected completion time: 2011

Michalina Komorowska, Faculty of Physics, University of Warsaw
Supervisors: prof. M. Kicińska-Habior, dr J. Srebrny. Expected completion time: 2011

D.1.7 Other BSc and MSc theses based on experiments performed at HIL

Agnieszka Żywno, Faculty of Physics, University of Warsaw
Nowe technologie w budowie skanerów dla diagnostyki medycznej
New technologies for construction of medical diagnostics scanners
Supervisor: dr hab. Z. Szefliński. MSc thesis defended in 2010

Damian Karpiński, Faculty of Physics, University of Warsaw
Badanie korelacji kątowych kwantów gamma na wiązce ciężkich jonów jako źródło informacji spektroskopowych
Angular correlations of gamma rays measured in beam of heavy ions — a source of spectroscopic information
Supervisor: dr E. Grodner. MSc thesis defended in 2010

Łukasz Janiak, University of Łódź
Wyznaczenie multipolowości przejść elektromagnetycznych na podstawie pomiarów koincydencyjnych elektron-gamma
Determination of multipolarities of electromagnetic transitions from electron-gamma coincidence measurements
Supervisor: dr J. Perkowski. MSc thesis defended in 2010

Michał Czerwiński, Faculty of Physics, University of Warsaw
Badanie skutków biologicznych promieniowania jonizującego
Biological effects of ionising radiation
Supervisor: dr hab. Z. Szefliński. BSc thesis defended in 2010

Onoufrios Sgouros, Physics Department, Univeristy of Ioannina, Greece
Elastic scattering of ^{20}Ne+^{28}Si at 74 MeV
Supervisor: prof. A. Pakou. Diploma thesis completed in 2011

Vasileios Soukeras, Physics Department, Univeristy of Ioannina, Greece
Reaction studies of ^{20}Ne+^{28}Si at 74 MeV
Supervisor: prof. A. Pakou. Diploma thesis completed in 2011

Ilona Głowacka, Faculty of Physics, University of Warsaw
Skuteczność biologiczna jonów węgla w zastosowaniu do terapii nowotworów
Biological effectiveness of carbon ions applied to cancer therapy
Supervisor: dr hab. Z. Szefliński. MSc thesis, expected completion time: 2011

Małgorzata Łoniewska, Faculty of Physics, University of Warsaw
Supervisor: dr hab. Z. Szefliński. BSc thesis, expected completion time: 2011

Aleksandra Rubin, Wojciech Piątek, Faculty of Mathematics and Natural Sciences, Cardinal Stefan Wyszyński University in Warsaw
Równoległe wyznaczanie wartości funkcji celu z wykorzystaniem architektury rozproszonej
Parallel determination of the objective function value based on a distributed application structure
Supervisors: prof. dr hab. J. Górecki, prof. dr hab. L. Socha.
BSc theses, expected completion time: 2011

Michał Czerwiński, Faculty of Physics, University of Warsaw
Supervisor: dr hab. Z. Szefliński. MSc thesis, expected completion time: 2012

D.2 Seminars

D.2.1 Seminars organised and co-organised by HIL

Nuclear Physics Seminars

Seminars organised jointly by the divisions of Nuclear Physics, Nuclear Spectroscopy and Nuclear Structure Theory of the Faculty of Physics, University of Warsaw, and Heavy Ion Laboratory, University of Warsaw

Waldemar Urban (Faculty of Physics, Univ. of Warsaw/ILL Grenoble, France) 17 February
Test symetrii tetrahedralnej w ^{156}Gd
Test of tetrahedral symmetry in ^{156}Gd

Krzysztof Rusek (HIL) 5 March
Środowiskowe — Narodowym? Teraźniejszość i przyszłość ŚLCJ UW
Towards National Laboratory: present status and future of HIL

Steven W. Yates (University of Kentucky, USA/TRIUMF, Canada) 10 March
Probing nuclear structure with fast neutrons

J. Srebrny (HIL) 24 March
Izomer K w ^{132}Ce. Wpływ nieosiowego kształtu jądra na osłabienie czystości liczby kwantowej K. Dowód experymentalny?
K isomer in ^{132}Ce. Influence of non-axial nuclear shape on weakening of the K number forbiddenness. The experimental proof?

Marek Olechowski (Faculty of Physics, University of Warsaw) 14 April
Ciemna materia — przegląd wyników doświadczalnych i modeli teoretycznych
Dark matter — an overview of experimental results and theoretical models

Marek Demiański (Faculty of Physics, University of Warsaw) 23 April
Gwiazdy neutronowe z perspektywy Jabłonnej
Neutron stars from Jabłonna perspective

Jacek Dobaczewski (Faculty of Physics, University of Warsaw,
University of Jyväskylä, Finland) 28 April
Nowe idee w jądrowych zastosowaniach metody funkcjonału gęstości
New ideas in the nuclear energy density functional approach

Amnon Marinov (Jerusalem University, Izrael) 12 May
High spin super- and hyper-deformed isomeric states and long-lived super-heavy elements

Seminars "Nuclear Physics in Medicine"

Seminars organised jointly by the Heavy Ion Laboratory, University of Warsaw, and the Division of Nuclear Medicine, Medical University of Warsaw

Zygmunt Szefliński (Faculty of Physics, University of Warsaw) 4 March
Impresje z warsztatów "Physics for Health in Europe", CERN, 2–4 lutego 2010
Impressions from the conference "Physics for Health in Europe", CERN, 2–4 February 2010

Ian Norton (Philips Health Care, Switzerland) 6 July
Radiation Oncology Imaging and Planning

HIL seminars

Ivan Ivanenko (JINR Dubna, Russia) 4 February
Compensation of the beam vertical defocusing at the exit of U400 cyclotron spiral inflector

Yoshitaka Fujita (Osaka University, Japan) 26 March
Gamow-Teller transitions: vivid nuclear weak process in the Universe

D.2.2 External seminars given by the HIL staff

J. Sura 19 January
The Thomson Parabola Spectrometer as laser ion beam analyser
Seminar of the Faculty of Physics, University of Messina, Italy

E. Piasecki 20 January
Rozkłady wysokości barier: pytania i odpowiedzi
Fusion barrier distributions: questions and answers
Seminar "Nuclear Structure", Faculty of Physics, University of Warsaw, Warsaw, Poland

J. Choiński 1 February
Centrum Badawczo-Produkcyjne Radiofarmaceutyków w Uniwersytecie Warszawskim
Radiopharmaceuticals Production and Research Centre at the University of Warsaw
Meeting of the National Atomic Energy Agency Commissions: Commission for Medical Applications of Ionising Radiation and Commission for Nuclear and Radiation Chemistry, Gliwice, Poland

L. Pieńkowski 22 February
Reaktory jądrowe typu HTR jako skondensowane źródło ciepła. W stronę synergii węglowo-jądrowej
HTR nuclear reactors as a compact energy source. Towards nuclear-coal synergy
invited talk at XIX School of Underground Exploitation, Kraków, Poland

J. Mierzejewski 19 March
Badanie mechanizmu reakcji niekompletnej fuzji — symulacje Monte-Carlo i pomiary na wiązce Warszawskiego Cyklotronu
Studying the incomplete fusion reaction mechanism — Monte-Carlo simulations and in-beam measurements at the Warsaw Cyclotron
Seminar of the Nuclear Physics Division, Faculty of Physics, University of Warsaw, Warsaw, Poland

M. Palacz 22 March
NEDA simulations status report
NEDA collaboration meeting, Legnaro, Italy

K. Rusek 23 March
Laboratorium: teraźniejszość i przyszłość ŚLCJ UW
Present status and future of HIL
Seminar of the Centre for Hadron Physics, Jagiellonian University, Kraków, Poland

P. Napiorkowski 4 May
Coulomb excitation of the presumably super-deformed band in ^{42}Ca: preliminary results from the first AGATA Demonstrator experiment
AGATA Physics Workshop, Istanbul, Turkey

J. Srebrny 19 May
Mechanism of weakening of the K-forbiddenness in ^{132}Ce: triaxiality or s-band — yrast-band interaction?
Workshop on Nuclear Isomers: Structure and Applications, University of Surrey, Guildford, UK

K. Hadyńska-Klęk 21 May
Wzbudzenie kulombowskie pasma przypuszczalnie superzdeformowanego w ^{42}Ca. Wstępne rezultaty pierwszego eksperymentu przeprowadzonego z wykorzystaniem spektrometru AGATA Demonstrator
Coulomb excitation of the presumably super-deformed band in ^{42}Ca — preliminary results

from the first AGATA Demonstrator experiment
Seminar of the Nuclear Physics Division, Faculty of Physics, University of Warsaw, Warsaw, Poland

W. Gawlikowicz 26 May
Dynamiczna emisja fragmentów w zderzeniach ciężkojonowych
Dynamical fragment emission in heavy ion collisions
Seminar "Nuclear Structure", Faculty of Physics, University of Warsaw, Warsaw, Poland

A. Kordyasz 2 June
Krzemowy detektor wierzchołkowy do identyfikacji pierwiastków superciężkich
Silicon vertex detector for superheavy elements identification
Seminar of the Division of Hot Matter, Jagiellonian University, Kraków, Poland

J. Kownacki 17 June
Detekcja materiałów rozszczepialnych używając wiązek wysokoenergetycznych fotonów (fotofission) w szczególności dzięki obserwacji neutronów opóźnionych
Detection of fissile materials using beams of high-energy photons (photofission) and following delayed neutron emission
Seminar of the P-III Department, Sołtan Institute for Nuclear Studies, Świerk, Poland

G. Jaworski 21 June
Jak zbadać coś podwójnie magicznego?
How to investigate a doubly-magic thing?
Annual Symposium of the Faculty of Physics, Warsaw University of Technology

A. Pękal 8 July
Zdolności antyutleniające ekstraktów z różnych rodzajów herbat
Antioxidant properties of various tea extracts
8th Polish Conference on Analytical Chemistry, Kraków, Poland

K. Hadyńska-Klęk 3 September
Coulomb excitation of the presumably super-deformed band in ^{42}Ca — preliminary results from the first AGATA Demonstrator experiment
45th Zakopane Conference on Nuclear Physics "Extremes of the Nuclear Landscape", Zakopane, Poland

K. Wrzosek-Lipska 3 September
Coulomb excitation of ^{100}Mo
45th Zakopane Conference on Nuclear Physics "Extremes of the Nuclear Landscape", Zakopane, Poland

P. Napiorkowski 8 September
Tests of cubic 2×2×2 $LaBr_3$ in Cracow and in Warsaw
PARIS collaboration meeting, Orsay, France

J. Jastrzębski 9 September
Metody wytwarzania radiofarmaceutyków dla tomografii pozytonowej
Methods for production of radiopharmaceuticals for positron emission tomography
invited talk at XII Scientific Convention of the Polish Society of Nuclear Medicine, Wrocław, Poland

A. Stolarz 17 September
Hydrogen-rich thin layers
25th INTDS World Conference, TRIUMF, Vancouver, Canada

A. Stolarz 17 September
Target set-up for measurements with Si-ball
25th INTDS World Conference, TRIUMF, Vancouver, Canada

L. Pieńkowski 24 September
Kogeneracja jądrowa
Nuclear cogeneration
International Conference "Nuclear Energy: Technologies, Investments", Warszawa, Poland

K. Wrzosek-Lipska 25 September
Shape evolution in even-even Mo isotopes studied via Coulomb excitation
invited talk at XVII Nuclear Physics Workshop "Marie & Pierre Curie", Kazimierz Dolny, Poland

J. Srebrny 25 September
Model independent determination of quadrupole deformation parameters from Coulomb excitation measurements
invited talk at XVII Nuclear Physics Workshop "Marie & Pierre Curie", Kazimierz Dolny, Poland

K. Hadyńska-Klęk 25 September
Coulomb excitation of the presumably super-deformed band in ^{42}Ca — preliminary results from the first AGATA Demonstrator experiment
XVII Nuclear Physics Workshop "Marie & Pierre Curie", Kazimierz Dolny, Poland

M. Palacz 4 November
Status of NEDA simulations
NEDA collaboration meeting, IFIC Valencia, Spain

M. Palacz 4 November
Spectroscopy next to ^{100}Sn: 3n gating and where is ^{100}In
NEDA collaboration meeting, IFIC Valencia, Spain

G. Jaworski 4 November
First experimental validation of NEDA simulations
NEDA collaboration meeting, IFIC Valencia, Spain

G. Jaworski 4 November
Single NEDA detector simulation: size, and BC501A vs. BC537
NEDA collaboration meeting, IFIC Valencia, Spain

K. Hadyńska-Klęk 24 November
^{42}Ca COULEX — current status of the data analysis
10th AGATA Week, IPN Lyon, France

M. Palacz 25 November
Status of NEDA simulations
10th AGATA Week, IPN Lyon, France

D.2.3 Poster presentations

K. Kilian, A. Pękal
Oznaczanie pozostałości rozpuszczalników organicznych w radiofarmaceutykach PET statyczną metodą Headspace GC
Measuring traces of organic solvants in PET radiopharmaceuticals using static Headspace GC method
8th Polish Conference on Analytical Chemistry, 4–9 July 2010, Kraków, Poland

G. Jaworski
Optimizing the neutron detection capabilities of NEDA — the Neutron Detector Array for spectroscopy studies
45th Zakopane Conference on Nuclear Physics "Extremes of the Nuclear Landscape", 30 August – 5 September, Zakopane, Poland

D. Piętak
An application of genetic algorithm to the COULEX data analysis
45th Zakopane Conference on Nuclear Physics "Extremes of the Nuclear Landscape", 30 August – 5 September, Zakopane, Poland

D. Piętak
Statistical distribution of the genetic algorithm sampling with Schwefel's F7 objective function
7th IEEE International Conference on Signals and Electronic Systems — ICSES 2010, 7–10 September 2010, Gliwice, Poland

A. Pękal
Biopolifenole w ekstraktach z herbat
Biopolyphenols in tea extracts
V Conference "Analytical Applications of Liquid Chromatography", 14–15 October 2010, Warszawa, Poland

K. Kilian
Pracownia ^{11}C i ^{15}O
Laboratory of ^{11}C and ^{15}O
III CePT Scientific Conference, 4 November 2010, Warszawa, Poland

D.2.4 Science popularisation lectures

P. Napiorkowski — 19 May
Rzecz o PET
All about PET
Lecture closing the “EUREKA” competition for secondary schools, Warszawa, Poland

K. Kilian — 19 May
Diagnostyka medyczna
Medical diagnostics
Lecture closing the “EUREKA” competition for secondary schools, Warszawa, Poland

P. Napiorkowski — 31 May
Warszawski cyklotron: co to i po co?
Warsaw Cyclotron: what is it and what does it serve for?
Lecture at the scientific camp of the Polish Children’s Fund, Świder, Poland

K. Kilian — 20 September
Zastosowania fizyki jądrowej w diagnostyce medycznej
Nuclear physics applications for medical diagnostics
XIV Festival of Science, 18–26 September 2010, Warszawa, Poland

J. Srebrny (moderator) — 20 September
Fizyka jądrowa — przeszłość, teraźniejszość i przyszłość
Nuclear physics — past, present and future
Panel discussion at the XIV Festival of Science, 18–26 September 2010, Warszawa, Poland

L. Pieńkowski — 21 September
Czym polecieć na Marsa?
How to reach Mars?
XIV Festival of Science, 18–26 September 2010, Warszawa, Poland

J. Jastrzębski, K. Kilian (moderators) — 21 September
Fizyka jądrowa w medycynie — radiofarmaceutyki, PET i terapia hadronowa
Nuclear physics in medicine — radiopharmaceuticals, PET and hadronotherapy
Panel discussion at the XIV Festival of Science, 18–26 September 2010, Warszawa, Poland

L. Pieńkowski (moderator) — 22 September
Energetyka jądrowa — czym fascynuje, a czym niepokoi?
Nuclear energy — what is so fascinating and scary about it?
Panel discussion at the XIV Festival of Science, 18–26 September 2010, Warszawa, Poland

P. Napiorkowski 24 September
Fizyka dla bramkarzy
Physics for goalkeepers
XIV Festival of Science, 18–26 September 2010, Warszawa, Poland

P. Napiorkowski, K. Hadyńska-Klęk 24 September
Radioaktywne materiały — naturalne składniki Ziemi
Radioactive materials — natural Earth components
Researchers' Night, 24 September 2010, Warszawa, Poland

D.2.5 Lectures for students

G. Jaworski 11 January
Środowiskowe Laboratorium Ciężkich Jonów
Presentation of the Heavy Ion Laboratory
Faculty of Physics (IV year), Warsaw University of Technology, Warszawa, Poland

K. Kilian 25 March
Radiofarmaceutyki do pozytronowej tomografii emisyjnej (PET). Nowe możliwości dla nauki, ochrony zdrowia i przemysłu
Radiopharmaceuticals for Positron Emission Tomography (PET). New perspectives for science, health care and industry
Faculty of Biology (II year), University of Warsaw, Warszawa, Poland

K. Kilian 30 April
Radiofarmaceutyki do pozytronowej tomografii emisyjnej (PET). Nowe możliwości dla nauki, ochrony zdrowia i przemysłu
Radiopharmaceuticals for Positron Emission Tomography (PET). New perspectives for science, health care and industry
Medical College in Radom (I,II year), Radom, Poland

M. Zielińska 24 May
Środowiskowe Laboratorium Ciężkich Jonów
Presentation of the Heavy Ion Laboratory
Faculty of Physics, Astronomy and Informatics (I year), Nicolaus Copernicus University, Toruń, Poland

M. Zielińska 14–21 June
Coulomb excitation data analysis using the GOSIA code
Oliver Lodge Laboratory, University of Liverpool, UK

K. Kilian 27 November
Radiofarmaceutyki do pozytronowej tomografii emisyjnej (PET)
Radiopharmaceuticals for Positron Emission Tomography (PET)
Students' Scientific Association, Faculty of Physics, Uniwersity of Warsaw, Warszawa, Poland

K. Rusek 6–10 December
Nuclear reactions on a computer
Faculty of Physics, Al-Farabi Kazakh National University, Almaty, Kazakhstan

K. Kilian 10 December
Radiofarmaceutyki do pozytronowej tomografii emisyjnej (PET)
Radiopharmaceuticals for Positron Emission Tomography (PET)
Faculty of Physics (IV year), Warsaw University of Technology, Warszawa, Poland

M. Palacz 10 December
Środowiskowe Laboratorium Ciężkich Jonów
Presentation of the Heavy Ion Laboratory
Faculty of Physics (IV year), Warsaw University of Technology, Warszawa, Poland

K. Kilian 12 December
Radiofarmaceutyki do pozytronowej tomografii emisyjnej (PET)
Radiopharmaceuticals for Positron Emission Tomography (PET)
Faculty of Physics (III year), Warsaw University of Technology, Warszawa, Poland

D.3 Involvement of the HIL staff in organisation of conferences and workshops

4th International Freiberg Conference on IGCC & XtL Technologies
2–6 May 2010, Dresden, Germany
Member of the Advisory Board: L. Pieńkowski

25th INTDS World Conference
12–17 September 2010, TRIUMF, Vancouver, Canada
Member of the Scientific Advisory Committee: A. Stolarz

XVII Nuclear Physics Workshop "Marie & Pierre Curie"
22–26 September 2010, Kazimierz Dolny, Poland
Member of the Advisory Board: J. Srebrny
Member of the Local Organising Committee: M. Zielińska

XIV Festival of Science
18–26 September 2010, Warszawa, Poland
Local Coordinator: K. Hadyńska-Klęk

Researchers' Night
24 September 2010, Warszawa, Poland
Local Coordinator: K. Hadyńska-Klęk

5th International Conference on High Temperature Reactor Technology HTR 2010
18–20 October 2010, Prague, Czech Republic
Member of the International Organising Committee: L. Pieńkowski

VI Polish Workshop on Acceleration and Applications of Heavy Ions
24–30 October 2010, Heavy Ion Laboratory, Warszawa, Poland
Local Organising Committee: P. Napiorkowski, A. Trzcińska

III CePT Scientific Conference
4 November 2010, Warszawa, Poland
Member of the Local Organising Committee: K. Kilian

D.4 Publications

D.4.1 ISI listed publications

Publications resulting from work performed with HIL facilities

J. Kownacki, C. Droste, T. Morek, E. Ruchowska, M. Kisieliński, M. Kowalczyk, R.M. Lieder, J. Perkowski, J. Andrzejewski, P.J. Napiorkowski, K. Wrzosek-Lipska, M. Zielińska, A. Kordyasz, A. Korman, W. Czarnacki, K. Hadyńska-Klęk, E. Grodner, J. Srebrny, J. Mierzejewski, A. Król,
Nuclear spectroscopy above isomers in $^{148}Ho_{81}$ and $^{149}Ho_{82}$ nuclei: Search for core-excited states in ^{149}Ho
Phys. Rev. **C81** (2010) 044305

A.T. Rudchik, Y.O. Shyrma, K.W. Kemper, K. Rusek, E.I. Koshchy, S. Kliczewski, B.G. Novatsky, O.A. Ponkratenko, E. Piasecki, G.P. Romanyshyna, Y.M. Stepanenko, I. Strojek, S.B. Sakuta, A. Budzanowski, L. Głowacka, I. Skwirczyńska, R. Siudak, J. Choiński, A. Szczurek,
Isotopic effects in elastic and inelastic $^{12}C+^{16,18}O$ scattering
Eur. Phys. J. **A44** (2010) 221

A. Wieloch, Z. Sosin, P. Banka, A. Gonciarz, J. Peter, A. Drouart, R. Dayras, K. Łojek, C. Stodel, M. Adamczyk, B. Avez, P. Lasko, L. Zosiak, T. Kozik, N. Alamanos, A. Gillibert, S. Grevy, F. Hanappe, F. Hannachi, R. Hue, A. Khouaja, A. Lopez-Martens, L. Manduci, F. de Oliveira Santos, G. Politi, M.G. Saint-Laurent, L. Stuttge, C. Vandamme, J.P. Wieleczko, E. Piasecki, A. Trzcińska, W. Gawlikowicz, M. Kisieliński, M. Kowalczyk, A. Kordyasz, J. Błocki,
New detector system for super heavy elements detection
Int. J. Mod. Phys. **E19** (2010) 672

J. Braziewicz, M. Polasik, K. Słabkowska, U. Majewska, D. Banaś, M. Jaskóła, A. Korman, K. Kozioł, W. Kretschmer, J. Choiński,
Equilibrium K-, L-, and M-shell ionizations and charge-state distribution of sulfur projectiles passing through solid targets
Phys. Rev. **A82** (2010) 022709

Publications resulting from work performed with facilities outside HIL

A. Trzcińska
Antiprotonic atoms as a tool to study the nuclear periphery
Acta Phys. Pol. **B41** (2010) 311

K. Schmidt, A. Benisz, A. Bubak, A. Grzeszczuk, S. Kowalski, W. Zipper, F. Amorini, A. Anzalone, L. Auditore, V. Baran, J. Brzychczyk, G. Cardella, S. Cavallaro, M.B. Chatterjee, M. Colonna, E. DeFilippo, M. DiToro, W. Gawlikowicz, E. Geraci, P. Guazzoni, E. La Guidara, G. Lanzalone, J. Łukasik, C. Maiolino, Z. Majka, N. Nicolis, A. Pagano, M. Papa, E. Piasecki, S. Pirrone, R. Płaneta, G. Politi, F. Porto, F. Rizzo, P. Russotto, K. Siwek-Wilczyńska, I. Skwira-Chalot, A. Sochocka, Ł. Świderski, A. Trifiro, M. Trimarchi, J.P. Wieleczko, J. Wilczyński, L. Zetta
Light fragments production and isospin dependences in Sn+Ni and Sn+Al central collisions at 25 MeV/A and 35 MeV/A from REVERSE/ISOSPIN experiments
Acta Phys. Pol. **B41** (2010) 387

J. Benlliure, D. Dragosavac, D. Perez-Loureiro, H. Alvarez-Pol, B. Blank, E. Casarejos, V. Fohr, M. Gascon, W. Gawlikowicz, A. Heinz, K. Helariutta, S. Lukic, F. Montes, L. Pieńkowski, M. Staniou, K. Subotic, K. Summerer, J. Taieb, A. Trzcińska, M. Veselsky,
Investigating the radial distributions of medium-mass nuclei
Nucl. Phys. **A834** (2010) 467c

M. Scheck, T. Grahn, A. Petts, P.A. Butler, A. Dewald, L.P. Gaffney, M.B. Gomez Hornillos, A. Görgen, P.T. Greenlees, K. Helariutta, J. Jolie, P. Jones, R. Julin, S. Juutinen, S. Ketelhut, T. Kröll, R. Krücken, M. Leino, J. Ljungvall, P. Maierbeck, B. Melon, M. Nyman, R.D. Page, J. Pakarinen, E.S. Paul, T. Pissulla, P. Rahkila, J. Saren, C. Scholey, A. Semchenkov, J. Sorri, J. Uusitalo, R. Wadsworth, M. Zielińska,
Lifetimes of odd-spin yrast states in ^{182}Hg
Phys. Rev. **C81** (2010) 014310

W. Gawlikowicz, D.K. Agnihotri, S.A. Baldwin, W.U. Schroder, J. Toke, R.J. Charity, D.G. Sarantites, L.G. Sobotka, R.T. Desouza, T. Barczyk, K. Grotowski, S. Micek, R. Płaneta, Z. Sosin,
Correlations between reaction product yields as a tool for probing heavy-ion reaction scenarios
Phys. Rev. **C81** (2010) 014604

J. Wilczyński, I. Skwira-Chalot, K. Siwek-Wilczyńska, A. Pagano, F. Amorini, A. Anzalone, L. Auditore, V. Baran, J. Brzychczyk, G. Cardella, S. Cavallaro, M.B. Chatterjee, M. Colonna, E. De Filippo, M. Di Toro, W. Gawlikowicz, E. Geraci, A. Grzeszczuk, P. Guazzoni, S. Kowalski, E. La Guidara, G. Lanzalone, J. Łukasik, C. Maiolino, Z. Majka, N.G. Nicolis, M. Papa, E. Piasecki, S. Pirrone, R. Płaneta, G. Politi, F. Porto, F. Rizzo, P. Russotto, K. Schmidt, A. Sochocka, Ł. Świderski, A. Trifiro, M. Trimarchi, J.P. Wieleczko, L. Zetta, W. Zipper,
Observation of fast collinear partitioning of the ^{197}Au+^{197}Au system into three and four fragments of comparable size
Phys. Rev. **C81** (2010) 024605

K. Zerva, A. Pakou, K. Rusek, N. Patronis, N. Alamanos, X. Aslanoglou, D. Filipescu, T. Glodariu, N. Keeley, M. Kokkoris, M. La Commara, A. Lagoyannis, M. Mazzocco, N.G. Nicolis, D. Pierroutsakou, M. Romoli,
Probing the potential and reaction coupling effects of $^{6,7}Li+^{28}Si$ at sub- and near-barrier energies with elastic backscattering
Phys. Rev. **C81** (2010) 044607

J. Ljungvall, A. Görgen, A. Obertelli, W. Korten, E. Clément, G. de France, A. Bürger, J.P. Delaroche, A. Dewald, A. Gadea, L. Gaudefroy, M. Girod, M. Hackstein, J. Libert, D. Mengoni, F. Nowacki, T. Pissulla, A. Poves, F. Recchia, M. Rejmund, W. Rother, E. Sahin, C. Schmitt, A. Shrivastava, K. Sieja, J.J. Valiente-Dobon, K.O. Zell, M. Zielińska,
Onset of collectivity in neutron-rich Fe isotopes: Toward a new island of inversion?
Phys. Rev. **C81** (2010) 061301

P. Russotto, E. De Filippo, A. Pagano, E. Piasecki, F. Amorini, A. Anzalone, L. Auditore, V. Baran, I. Berceanu, J. Blicharska, B. Borderie, R. Bougault, M. Bruno, J. Brzychczyk, G. Cardella, S. Cavallaro, M.B. Chatterjee, A. Chbihi, M. Colonna, M. D'Agostino, R. Dayras, M. Di Toro, J. Frankland, E. Galichet, W. Gawlikowicz, E. Geraci, F. Giustolisi, A. Grzeszczuk, P. Guazzoni, D. Guinet, S. Kowalski, E. La Guidara, G. Lanzalone, G. Lanzano, N. Le Neindre, C. Maiolino, Z. Majka, M. Papa, M. Petrovici, S. Pirrone, R. Płaneta, G. Politi, A. Pop, F. Porto, M.F. Rivet, F. Rizzo, E. Rosato, K. Schmidt, K. Siwek-Wilczyńska, I. Skwira-Chalot, A. Trifiro, M. Trimarchi, M. Vigilante, J.P. Wieleczko, J. Wilczyński, L. Zetta, W. Zipper,
Strong enhancement of dynamical emission of heavy fragments in the neutron-rich $^{124}Sn+^{64}Ni$ reaction at 35 AMeV
Phys. Rev. **C81** (2010) 064605

J. Wilczyński, I. Skwira-Chalot, K. Siwek-Wilczyńska, A. Pagano, F. Amorini, A. Anzalone, L. Auditore, V. Baran, J. Brzychczyk, G. Cardella, S. Cavallaro, M.B. Chatterjee, M. Colonna, E. De Filippo, M. Di Toro, W. Gawlikowicz, E. Geraci, A. Grzeszczuk, P. Guazzoni, S. Kowalski, E. La Guidara, G. Lanzalone, J. Łukasik, C. Maiolino, Z. Majka, N.G. Nicolis, M. Papa, E. Piasecki, S. Pirrone, R. Płaneta, G. Politi, F. Porto, F. Rizzo, P. Russotto, K. Schmidt, A. Sochocka, Ł. Świderski, A. Trifiro, M. Trimarchi, J.P. Wieleczko, L. Zetta, W. Zipper,
Aligned breakup of heavy nuclear systems as a new type of deep inelastic collisions at small impact parameters
Phys. Rev. **C81** (2010) 067604

N. Keeley, N. Alamanos, K.W. Kemper, K. Rusek,
Strong nuclear couplings as a source of Coulomb rainbow suppression
Phys. Rev. **C82** (2010) 034606

A.M. Bruce, S. Lalkovski, A.M.D. Bacelar, M. Górska, S. Pietri, Z. Podolyak, Y. Shi, P.M. Walker, F.R. Xu, P. Bednarczyk, L. Caceres, E. Casarejos, I.J. Cullen, P. Doornenbal, G.F. Farrelly, A.B. Garnsworthy, H. Geissel, W. Gelletly, J. Gerl, J. Grębosz, C. Hinke, G. Ilie, G. Jaworski, I. Kojouharov, N. Kurz, S. Myalski, M. Palacz, W. Prokopowicz, P.H. Regan, H. Schaffner, S. Steer, S. Tashenov, H.J. Wollersheim,
Shape coexistence and isomeric states in neutron-rich ^{112}Tc and ^{113}Tc
Phys. Rev. **C82** (2010) 044312

A. Ekström, J. Cederkäll, C. Fahlander, M. Hjorth-Jensen, T. Engeland, A. Blazhev, P.A. Butler, T. Davinson, J. Eberth, F. Finke, A. Görgen, M. Górska, A.M. Hurst, O. Ivanov, J. Iwanicki, U. Köster, B.A. Marsh, J. Mierzejewski, P. Reiter, S. Siem, G. Sletten, I. Stefanescu, G.M. Tveten, J. Van de Walle, D. Voulot, N. Warr, D. Weisshaar, F. Wenander, M. Zielińska,
Coulomb excitation of the odd-odd isotopes ^{106,108}In
Eur. Phys. J. **A44** (2010) 355

D.4.2 Other conference contributions

A.J. Kordyasz, M. Kowalczyk, A. Bednarek, L. Bardelli, R. Bougault, L. Lavergne, J. Sarnecki, M. Kisieliński, A. Brzozowski, K. Pytel, M. Tarchalski, J. Tarasiuk, P. Grabiec, A. Panas,
Determination of Si wafer resistivity distribution by C-V measurements
Proceedings of Science (RD09) 016

D.4.3 Internal reports

M. Kopka, P. Krysiak, W. Kozaczka Z. Morozowicz, K. Pietrzak
Instrukcje wykonywania połączeń rezerwowych rozdzielni głównych w budynku ŚLCJ
Realisation of reserve connections to the main switchboards — manual

M. Kopka, P. Krysiak, W. Kozaczka, Z. Morozowicz, K. Pietrzak
Projekt powykonawczy. Budowa układu wentylacji pomieszczenia kompresorni
As-built design for mechanical ventilation system at the compressor cave

M. Kopka, W. Kozaczka
Pomiary parametrów sieci energetycznej zasilającej Generatory W. Cz.
Measurements of the parameters of the electric power system of high frequency generators

M. Kopka, W. Kozaczka
Projekt i wykonanie elektromagnesów korekcyjnych dla ECR
Design and construction of the dipole electromagnets for the ECR beam line

M. Kopka, P. Krysiak, Z. Morozowicz, K. Pietrzak
Projekt powykonawczy. Budowa dodatkowych uziomów ŚLCJ
As-built design for additional earth electrodes of the HIL building

M. Kopka

Modernizacja rozdzielnic RG I, RG II i RG III w celu zwiększenia ciągłości zasilania ŚLCJ i Ośrodka PET

Modernisation of the RG I, RG II i RG III switchboards necessary for uninterrupted functioning of HIL and of the PET Centre

D.5 Awards

D.5.1 Heavy Ion Laboratory Prize founded by Prof. T. Inamura

The prize was established by Professor T.T. Inamura who had worked in the Heavy Ion Laboratory in years 1998-2002 and made a great contribution to HIL development. Award in the amount of 5.000 USD is granted every second year to recognise and support young researchers having outstanding experimental or technical achievements in the field of nuclear and atomic physics or related subjects. The results should be obtained by using the Warsaw Cyclotron or other HIL apparatus. Candidates must be scientists or PhD students below the age of 36 on the day of application. The most important selection criterion is the candidate's academic achievement demonstrated by publications in the international journals and presentations at international conferences. Achievements in the field of interdisciplinary applications of the HIL cyclotron are highly valued.
In the fourth edition, in 2010, the Heavy Ion Laboratory Prize has been awarded to **Katarzyna Wrzosek-Lipska** (HIL) for her achievements in the field of nuclear structure, in particular studies of shape coexistence in the heaviest stable ^{100}Mo isotope, performed at HIL using the Coulomb excitation technique.

D.5.2 Other awards granted to HIL staff and PhD students

Katarzyna Hadyńska-Klęk

Research scholarship for academic year 2010/2011 from the "PhD for Mazovia" project, funded by the European Social Fund in the framework of the Human Capital programme. The scholarships were awarded to the best PhD students at the University of Warsaw, pursuing research important for the industry of the Mazovia region.

Grzegorz Jaworski

Research scholarship for PhD students granted by the Center for Advanced Studies, Warsaw University of Technology, for 24 months since 1 October 2010. The scholarship is funded be the European Social Fund and the Polish government and is awarded to the best PhD students of the Warsaw University of Technology, pursuing research in branches important for economy.

Katarzyna Wrzosek-Lipska

Conference grant from the Foundation for Polish Science, to cover participation in the Zakopane Conference on Nuclear Physics, 30 August-5 September 2010, Zakopane, Poland

Magdalena Zielińska

Research scholarship for academic year 2009/2010 from the "Modern University" project, funded by the European Social Fund in the framework of the Human Capital programme. The scholarships were awarded to the best young post-docs at the University of Warsaw.

International internship for a young post-doc at the University of Liverpool, from the "Modern University" project, funded by the European Social Fund in the framework of the Human Capital programme.

D.6 Laboratory staff

Director: Krzysztof Rusek
Deputy directors: Jarosław Choiński, Magdalena Zielińska

Financial executive: Paweł Napiorkowski

Senior scientists:

Jerzy Jastrzębski, Jan Kownacki[1], Andrzej Kordyasz, Ernest Piasecki[1], Ludwik Pieńkowski, Krzysztof Rusek, Józef Sura

Scientific staff and engineers:

Tomasz Abraham, Andrzej Bednarek, Izabela Cydzik[2], Jarosław Choiński, Bohdan Filipiak[1], Wojciech Gawlikowicz[3], Przemysław Gmaj, Jędrzej Iwanicki[2], Andrzej Jakubowski, Viatcheslav Khrabrov, Krzysztof Kilian, Maciej Kisieliński[1], Marian Kopka, Michał Kowalczyk[1], Janusz Kurzyński[1], Ireneusz Mazur, Jan Mierzejewski, Jan Miszczak, Paweł Napiorkowski, Marcin Palacz, Anna Pękal[1], Daniel Piętak, Mateusz Sobolewski, Olga Steczkiewicz, Anna Stolarz, Julian Srebrny[1], Dorota Szczepaniak, Roman Tańczyk, Radosław Tarnowski, Agnieszka Trzcińska, Jan Tys[1], Marzena Wolińska-Cichocka[2], Magdalena Zielińska

Doctoral candidates:

Katarzyna Hadyńska-Klęk[4], Grzegorz Jaworski[5], Jan Mierzejewski[4], Daniel Piętak[6], Katarzyna Wrzosek-Lipska[4]

Technicians:

Mariusz Antczak, Tomasz Bracha, Marek Figat, Andrzej Górecki, Piotr Jasiński, Wiesław Kalisiewicz, Wojciech Kozaczka, Zbigniew Kruszyński, Piotr Krysiak, Krzysztof Łabęda-Dyszy, Zygmunt Morozowicz, Bogusław Paprzycki, Wiesław Perkowski[1], Andrzej Pietrzak, Krzysztof Pietrzak, Ryszard Pozorek, Irena Skrzeczanowska, Krzysztof Sosnowski

Administration and support:

Anna Błaszczyk-Duda, Marek Budziszewski, Rafał Klęk, Agnieszka Maciejewska, Ewa Sobańska, Lidia Strzelczyk, Krystyna Szczepaniak, Iwona Tomaszewska, Joanna Wasilewska, Wanda Wesoły, Andrzej Wiechowski, Irena Żejmo[1]

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[1]part time
[2]on long term leave
[3]till 30 September 2010
[4]PhD student at the Institute of Experimental Physics, University of Warsaw
[5]PhD student at the Faculty of Physics, Warsaw University of Technology
[6]PhD student at the Department of Electronics and Information Technology, Warsaw University of Technology

D.7 Laboratory Council

1. Prof. dr hab. Józef Andrzejewski
Nuclear Physics Division,
University of Łódź
90-236 Łódź, ul. Pomorska 149/153

2. Prof. dr hab. Janusz Braziewicz
Institute of Physics,
Jan Kochanowski University
25-406 Kielce, ul. Świętokrzyska 15

3. Prof. dr hab. inż. Andrzej Chmielewski
Institute of Nuclear Chemistry
and Technology
03-195 Warszawa, ul. Dorodna 16

4. Prof. dr hab. inż. Jacek Jagielski
Institute of Electronic Materials
and Technology
01-919 Warszawa, ul. Wólczyńska 133

5. Prof. dr hab. Jerzy Jastrzębski
Heavy Ion Laboratory,
University of Warsaw
02-093 Warszawa, ul. Pasteura 5A

6. Prof. dr hab. Marta Kicińska-Habior
University of Warsaw
00-681 Warszawa, ul. Hoża 69

7. inż. Marian Kopka
(representative of the HIL staff)
Heavy Ion Laboratory,
University of Warsaw
02-093 Warszawa, ul. Pasteura 5A

8. Prof. dr hab. Paweł Kulesza
Faculty of Chemistry,
University of Warsaw
02-093 Warszawa, ul. Pasteura 1

9. Prof. dr hab. inż. Tadeusz Kulik
Warsaw University of Technology
00-661 Warszawa, pl. Politechniki 1

10. Prof. dr hab. Adam Maj
The Henryk Niewodniczański
Institute of Nuclear Physics,
Polish Academy of Sciences
31-342 Kraków, ul. Radzikowskiego 152

11. Dr hab. Sławomir Nazarewski
Medical University of Warsaw
02-091 Warszawa, ul. Żwirki i Wigury 61

12. Prof. dr hab. Paweł Olko
The Henryk Niewodniczański
Institute of Nuclear Physics,
Polish Academy of Sciences
31-342 Kraków, ul. Radzikowskiego 152

13. Prof. dr hab. Marek Pfutzner
Faculty of Physics, University of Warsaw
00-681 Warszawa, ul. Hoża 69

14. Prof. dr hab. Ernest Piasecki
Heavy Ion Laboratory,
University of Warsaw
02-093 Warszawa, ul. Pasteura 5A

15. Dr hab. Ludwik Pieńkowski
(Chairman of the Council)
Heavy Ion Laboratory,
University of Warsaw
02-093 Warszawa, ul. Pasteura 5A

16. Prof. dr hab. Krzysztof Pomorski
Maria Curie-Skłodowska University
20-031 Lublin, ul. Radziszewskiego 10

17. Prof. dr hab. Krzysztof Rusek
(Director of HIL)
Heavy Ion Laboratory,
University of Warsaw
02-093 Warszawa, ul. Pasteura 5A

18. Prof. dr hab. Teresa Rząca-Urban
Faculty of Physics, University of Warsaw
00-681 Warszawa, ul. Hoża 69

19. Prof. dr hab. Adam Sobiczewski
The Andrzej Sołtan Institute
for Nuclear Studies
00-681 Warszawa, ul. Hoża 69

20. Prof. dr hab. Henryk Szymczak
Institute of Physics,
Polish Academy of Sciences
02-668 Warszawa, Al. Lotników 32/46

21. Prof. dr hab. Grzegorz Wrochna
The Andrzej Sołtan Institute
for Nuclear Studies
05-400 Świerk k/Warszawy

22. Prof. dr hab. Wiktor Zipper
A. Chełkowski Institute of Physics
University of Silesia
40-007 Katowice, ul. Uniwersytecka 4

D.8 Program Advisory Committee

PAC members

- Dimiter Balabanski (University of Sofia, Bulgaria)
- Konrad Czerski (Institute of Physics, University of Szczecin; Physics Department, Technical University of Berlin)
- Bogdan Fornal (Henryk Niewodniczański Institute of Nuclear Physics, Polish Academy of Sciences, Kraków)
- Gilles de France (GANIL, Caen, France)
- Andres Gadea (University of Valenzia, Spain)
- Zenon Janas (Faculty of Physics, University of Warsaw)
- Nicholas Keeley (The A. Sołtan Institute for Nuclear Studies, Warszawa)
- Rainer Lieder (University of Bonn, Germany)
- Piotr Magierski (Faculty of Physics, Warsaw University of Technology)
- Leszek Próchniak (Maria Curie-Skłodowska University, Lublin)
- Brunon Sikora (Faculty of Physics, University of Warsaw)
- Władysław Trzaska (University of Jyväskylä, Finland)

The international Program Advisory Committee of the Heavy Ion Laboratory meets usually twice a year, in spring and in autumn. Deadline for submitting proposals is three weeks before a PAC meeting. Due to a large backlog of approved experiments, there was only one PAC meeting in 2010, on 20 April. PAC approved experiments are scheduled at the meetings of the Users' Committee, which is also serving as a link between the cyclotron users and the Laboratory. The Users' Committee is chaired by Julian Srebrny (HIL UW).

D.9 Laboratory guests

Participants of HIL experiments from outside-Warsaw laboratories

J. Andrzejewski	University of Łódź, Poland
D. Banaś	Holycross Cancer Centre, Kielce, Poland
J. Braziewicz	Jan Kochanowski University, Kielce, Poland
J. Czub	Jan Kochanowski University, Kielce, Poland
M. Ducourtieux	IPN Orsay, France
L. Gaffney	University of Liverpool, UK
Ł. Janiak	University of Łódź, Poland
D. Judson	University of Liverpool, UK
M. Kasztelan	The Andrzej Sołtan Institute for Nuclear Studies, Łódź, Poland
P. Koczoń	GSI Darmstadt, Germany
E. Koshchiy	Kharkiv National University, Ukraine
A. Król	University of Łódź, Poland
A. Pakou	University of Ioannina, Greece
N. Patronis	University of Ioannina, Greece
J. Perkowski	University of Łódź, Poland
J. Samorajczyk	University of Łódź, Poland
M. Scheck	University of Liverpool, UK
A. Semsoum	IPN Orsay, France
J. Sheridan	Harvard University, USA
O. Sgouros	University of Ioannina, Greece
V. Soukaras	University of Ioannina, Greece
V. Werner	University of Yale, USA
M. Wrzesień	University of Łódź, Poland
S. Yates	University of Kentucky, USA/TRIUMF, Canada
K. Zerva	University of Ioannina, Greece

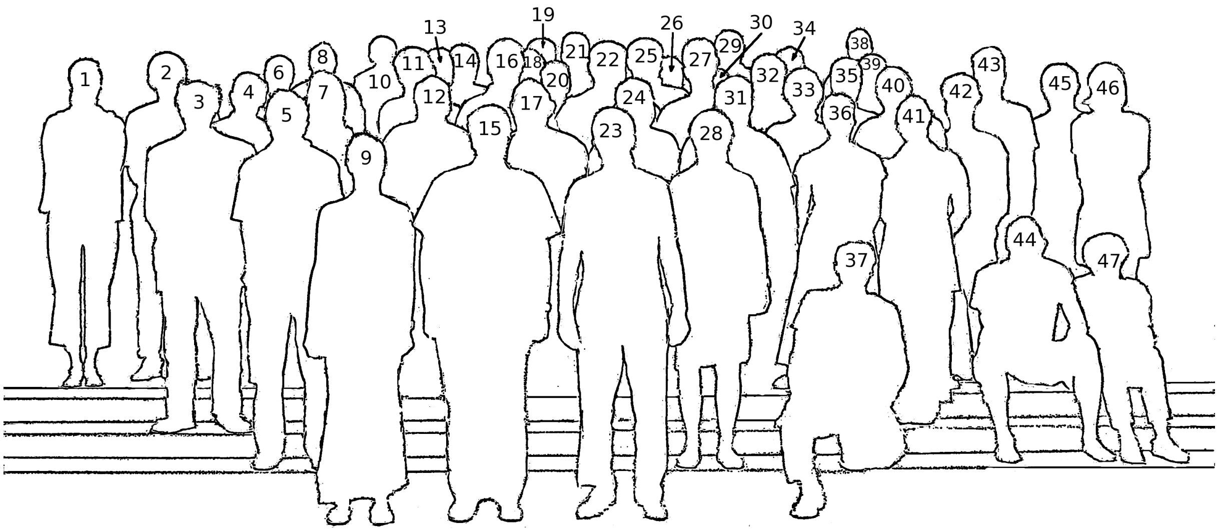
Other short-time visitors

N. Alamanos	CEA Saclay, France
V. Buzmakov	Joint Institute for Nuclear Research, Dubna, Russia
C. Domínguez	University of Huelva, Spain
F. Flavigny	CEA Saclay, France
I. Ivanenko	Joint Institute for Nuclear Research, Dubna, Russia
K.W. Kemper	Florida State University, Tallahassee, USA
L. Nalpas	CEA Saclay, France
A. Obertelli	CEA Saclay, France
R.P. Singh	Inter-University Accelerator Centre, New Delhi, India

Long-time visitors

M. Mateva	University of Sofia, Bulgaria (5 months)
K. Shegunov	University of Sofia, Bulgaria (5 months)
D. Tsoneva	University of Sofia, Bulgaria (5 months)
K. Zerva	University of Ioannina, Greece (3 months)

The title page photo shows the following people:



1. Olga Steczkiewicz
2. Przemysław Gmaj
3. Eryk Piasecki
4. Mateusz Sobolewski
5. Jerzy Jastrzębski
6. Krzysztof Łabęda-Dyszy
7. Dorota Szczepaniak
8. Piotr Krysiak
9. Magda Zielińska
10. Marek Figat
11. Irena Żejmo
12. Andrzej Pietrzak
13. Jan Miszczak
14. Andrzej Wiechowski
15. Jarosław Choiński
16. Roman Tańczyk
17. Andrzej Jakubowski
18. Zygmunt Morozowicz
19. Tomasz Bracha
20. Zbigniew Kruszyński
21. Wiesław Kalisiewicz
22. Piotr Jasiński
23. Krzysztof Rusek
24. Andrzej Kordyasz
25. Radosław Tarnowski
26. Krzysztof Pietrzak
27. Marian Kopka
28. Anna Stolarz
29. Wojciech Kozaczka
30. Bohdan Filipiak
31. Paweł Napiorkowski
32. Bogdan Paprzycki
33. Katarzyna Hadyńska-Klęk
34. Józef Sura
35. Jan Kownacki
36. Agnieszka Trzcińska
37. Rafał Klęk
38. Ludwik Pieńkowski
39. Marcin Palacz
40. Krzysztof Sosnowski
41. Anna Błaszczyk-Duda
42. Lidia Strzelczyk
43. Tomasz Abraham
44. Grzegorz Jaworski
45. Julian Srebrny
46. Katarzyna Wrzosek-Lipska
47. Michalina Komorowska