WARSAW UNIVERSITY
HEAVY ION LABORATORY

ANNUAL REPORT
2002

Warsaw University
Heavy Ion Laboratory

ANNUAL REPORT
2002

WARSAW, May 2003

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INTRODUCTION

In 2002, with nearly 3000 hours of the beam on target the machine acquired the operation efficiency allowing to fulfill almost all requests of the experimental teams using our facility. This year the technical upgrades were rather modest, limited mainly to what was possible to achieve using the limited resources of the Laboratory team. The phase and amplitude stabilization of the accelerating dee-voltage was certainly the major step toward the more stable and intense beam delivered to the experiments. Also, a beam of almost 10 AMeV energy was used during two weeks for the Giant Resonance experiment, showing that the beam with the designed energy can be reliably provided.

From the numerous published or terminated in 2002 results let me quote some representative achievements. In nuclear physics these are the studies of nuclear reactions between light nuclei ^{9}Be + ^{11}B and ^{12,13}C + ^{11}B, the publication of the first results on barriers distributions in ^{16}O + ^{116,119}Sn reaction, the continuation of the Giant Resonance studies, the OSIRIS group data on nuclei around ^{110}Sn, and the discovery of the shape coexistence in ^{98}Mo, using the light ion beam from our machine and heavier projectiles form JAERI cyclotron (Japan).

Interesting data were obtained and accepted for publication in Phys.Rev.A in atomic physics. Last but not least – our accelerator was used to test the plastic and Si detectors constructed in the Laboratory, the first one already used in some experiments abroad.

The mentioned above ^{98}Mo results as well as a number of other discussed projects in the domain of nuclear and solid state physics clearly indicate that there is a continuous and increasing need for the acceleration of heavier than A = 40 ions in our facility. This can only be done with a new ECR ion source, an investment which was not accepted during last two years by our Funding Agency.

As announced in the last year Annual Report our Laboratory was honored by the nomination to organize (in collaboration with the Institute of Nuclear Physics in Kraków) the XXXIII European Cyclotron Progress Meeting. The report on this meeting, to be published soon by Nuclear Physic News International can be also found in this Annual Report. In short, the conference was a very successful event, gathering almost 100 participants from Europe, USA, Canada and Japan. Its organization was supported by KBN, Polish National Atomic Agency and a number of commercial companies, mainly involved in the production of medical cyclotrons. The Proceedings of this meeting are presently in print in Nukleonika.

Besides the conference organization two other activities, not directly related to the machine operation and the resulting research outcome should be mentioned in this introduction.

First of them is related to the organizational challenges of the whole Polish Nuclear Physics community and its relations with the European Research Area. Heavy Ion Laboratory, fulfilling its role of the interinstitutional facility, play a leading role in the currently organized Polish Nuclear Physics Network. This network, a part of the larger structure including also nuclear research institutions from Czech Republic, Slovakia and Hungary enters the Integrated Infrastructure Initiative (I3) – EURONS, recently proposed for funding within the Six Framework Programme of the EC.

The second activity looks even further into the future of the Laboratory. Already two years ago, in collaboration with Nuclear Medicine Department of the neighboring Academy of Medicine Clinical Hospital, the Laboratory prepared a proposal for the installation in the Ochota Campus the first in Poland Position Tomography center. This Introduction is certainly not a place to enumerate all difficulties and problems encountered. In the mean time a PET center was inaugurated in the Oncological Hospital in Bydgoszcz showing that this new technique has also a future in Poland. In Warsaw, under the auspices of the Heavy Ion Laboratory a group of 13 medical and research centers formed a consortium, decided to continue a common search of funding for the PET Center in Warsaw. The present project envisages the production of the radioisotopes using a new compact cyclotron and the preparation of radiopharmaceuticals on the site of the Laboratory. The longest lived products will be transported to the Warsaw hospitals for diagnostical purposes. In addition an animal micro-PET scanner will be located close to the production cyclotron, boosting the research program of the neighboring experimental biology and medicine centers.

The PET activity of the Heavy Ion Laboratory, strongly oriented toward the achievement of the interdisciplinary character of our center will benefit from the experience of our staff in the accelerator techniques, already existing technical infrastructure and a large laboratory space available for this project. Its educational objectives are also very important for a center located in the heart of a scientific campus.

As can be judged from this Report, the scientific output of the Laboratory is kept at high level, resulting in the publications in the prestigious journals. I do hope, that in the next year's Annual Report the progress both in the scientific results gathered with the heavy ion machine as well as in of our PET project will continue. However, as always this only partly depend on the involvement, enthusiasm and hard work of our team but mainly on the decisions of the Governmental Funding Agencies.

Jerzy Jastrzębski

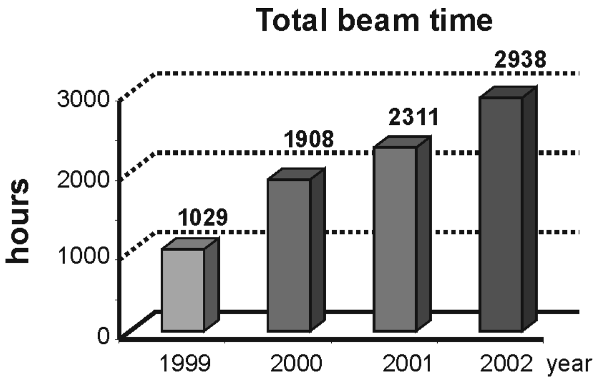
Part A:
Laboratory overview

1. Operation of the cyclotron and associated apparatus during 2002

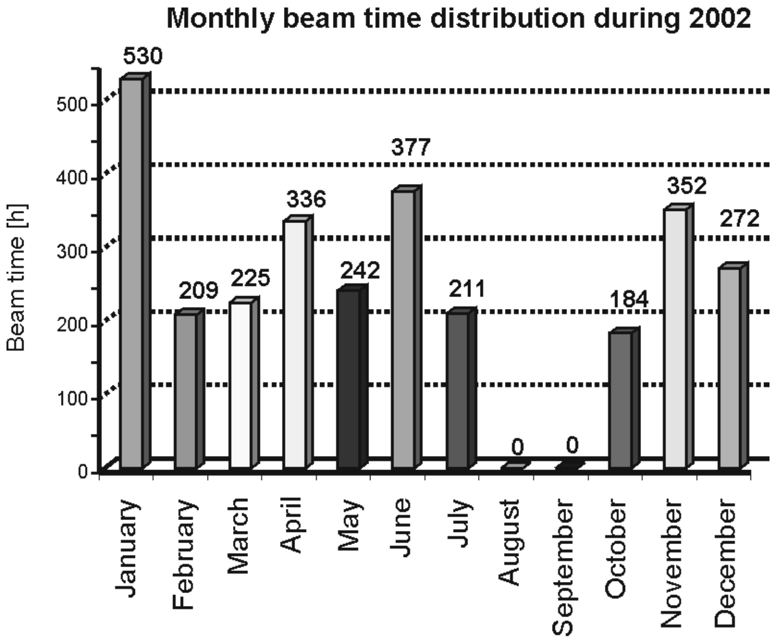
J. Choiński, T. Czosnyka, J. Dworski, J. Jastrzębski, J. Kownacki, E. Kulczycka, J. Kurzyński, J. Miszczak, A. Stolarz, K. Sudlitz, J. Sura, L. Zemło

Cyclotron facility

In 2002 the cyclotron delivered the beams-on-target for 2938 hours. A gradual increase of the beam time available to the users is illustrated in the figure below.



Monthly distribution of the beam time during 2002 is presented in the following figure. August and September was the vacation period, during which delayed leaves of the accelerator crew have been partly used.



In 2002 the buncher installed at the injection line was continuously in use. The experimental results in increasing the ion beam intensity (2 to 4 times dependent of the ion species) are encouraging and justify the effort to design a final variable geometry buncher, which is under way. Detailed calculations and design are given in HIL Report 4/02, as well as the description of the appropriate RF-system. The beams currently available (ions, energies and currents) are shown below.

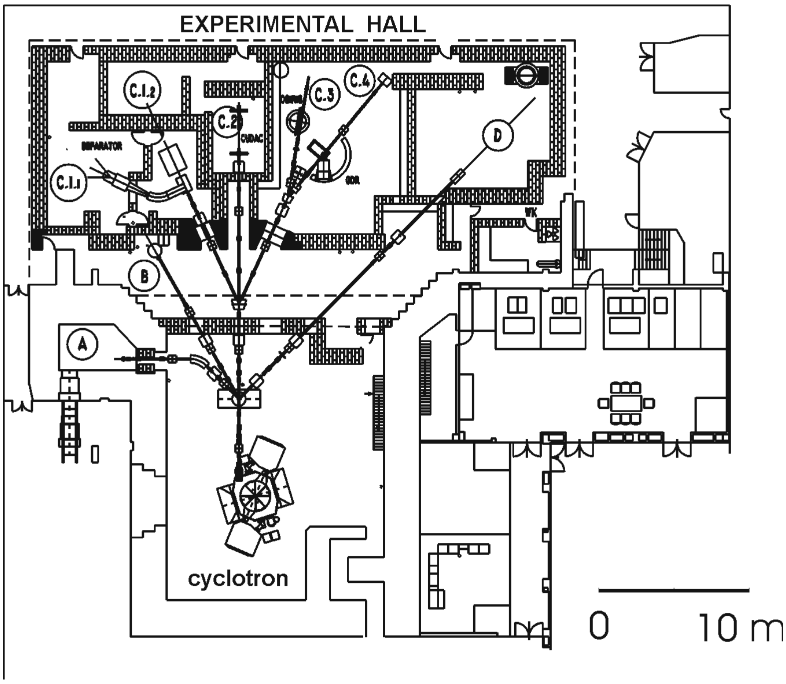
Available ions beams and their intensities.

Ion	Energy [MeV]	Extracted current [pnA]	Charge after extraction	Extraction radius [cm]
^{11}B^{+2}	38 - 55	3 – 4	5	71 - 85
^{12}C^{+2}	22 - 48	2 - 20	5, 6	56 - 83
^{14}N^{+2}	28 - 42	13 - 22	6	69 - 84
^{14}N^{+3}	70 - 84	100 - 143	7	72 - 79
^{16}O^{+2}	32	5.7	7	79
^{16}O^{+3}	46 - 80	5.7 - 137.5	7, 8	63 - 83
^{19}F^{+3}	38 - 66	1.25	8	62 - 82
^{20}Ne^{+4}	70 - 120	11 - 35	9, 10	65 - 85
^{20}Ne^{+5}	194	40	10	73
^{32}S^{+5}	64 – 121.6	0.5 – 1.4	13, 14	62 - 85
^{40}Ar^{+7}	120 - 172	0.9 – 2.3	16 - 18	69 - 82

Precise measurements of the beam energies were made possible by the installation of the time-of-flight system. Three induction coils permanently mounted on the first section of the beamline assure continuous monitoring of the beam energy with high precision (of the order of few hundreds keV).

Ion Beam Lines and Experiments

A schematic view of the experimental hall is reminded in the figure below. Lines C1, C2, C3 and C4 are used by permanent experimental set-ups while lines B and D accommodate the needs of the users having their own dedicated chambers.



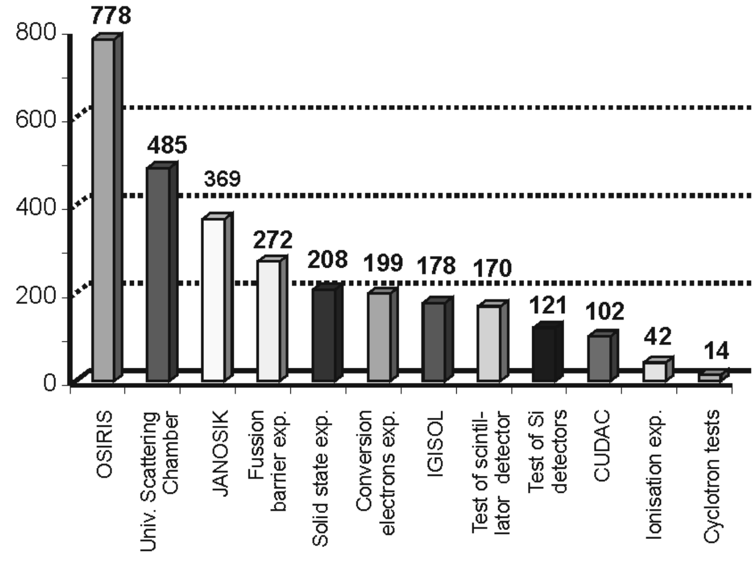
Schematic view of the experimental area.

Examples of experiments employing heavy ions beams from the cyclotron include:

1) Investigation of the high spin states of nuclei with the multidetector OSIRIS II system. The experimental set-up consists of 10 anticompton shielded HPGe detectors equipped with charged particle 4π multiplicity filter Si-Ball, 50 elements BGO γ-rays multiplicity filter and 4 sector HPGe polarimeter (line C3).
2) Coulomb Excitation (COULEX) studies. A permanent set-up for such investigations, consisting of an array of PIN-diodes (CUDAC - Coulomb Universal Detector Array Chamber) in connection with the computer data analysis package GOSIA, maintained by the Laboratory, attracts the scientists from many institutions (line C2). The same set-up is used for the investigation of fusion barriers via detection of scattered projectiles.
3) Investigation of the reaction products by means of the on-line mass separator with ion-guide system IGISOL - now in test phase. The system uses the Scandinavian-type mass separator built in Institute for Nuclear Studies, Świerk (line C1).
4) Reaction studies of the light nuclei using universal large scattering chamber at the line B equipped with the charged particles detectors (gas filled ionization counter as well as semiconductor detectors).
5) Giant Dipole Resonance studies using experimental set-up JANOSIK developed for the detection of high-energy photons emitted in heavy-ion collisions. The set-up consists of a large NaI(Tl) detector (25cm × 29cm) surrounded by shields: passive lead shield, active anticoincidence plastic shield and LiH shield to absorb neutrons, and a multiplicity filter of 32 small scintillator detectors (BaF_2 and NaI(Tl)) (line C4). During the GDR experiments 9.7 MeV/amu neon beam was used for the extended period, showing the operational possibilities of the accelerator in the 10 MeV/amu range.
6) Applications of heavy ion beams in solid state physics (internal or extracted beams).
7) Investigation of the ion-atom collision processes by X-ray spectroscopy using the Si(Li) detector (lines B or D). The scientific interest is concentrated on:
    a) studies of the X-ray emission from swift heavy projectiles slowing down in thin target foils,
    b) studies of the multiple ionization effect through the measurement of the L- and M-shells X-ray production cross section, X-ray shift and line broadening induced by heavy ions in selected heavy elements.

More details concerning the development of the apparatus for research projects can be found in the articles describing the ongoing activities presented in this Report.
The histogram of the beam time for different projects in 2002 is presented below.

Experiments from 1.01.2002 to 31.12.2002, total beam time 2 938 hours



Plans of Development

Depending on the financial condition of the Laboratory during the next few years the following major upgrades of the machine and its infrastructure are foreseen:

		Estimated completion time
1.	Cyclotron	
1.1.	Cyclotron upgrade	
1.1.1.	Improvement of phase and amplitude stability	2003
1.1.2.	Precise beam energy definition using time-of-flight method	2003
1.1.3.	Final version of the computerized remote control system	2004
2.	ECR ion source	
2.1.	Upgrade of the source	
2.1.1.	Computerized remote control system	2003
2.1.2.	Oven for production of the metallic ions	2003
2.2.	Second ECR ion source	funding - dependent
3.	Injection line for the second ECR ion source	funding - dependent

To summarize, the operation of the cyclotron in 2002 was definitely successful, with no major breakdowns due to technical problems. The engagement, expertise and perseverance of the technical staff to keep the accelerator up and running should be very much acknowledged.

2. Activity report of the ECR group

B. Filipiak, A. Górecki, Z. Kondeja, E. Kulczycka, K. Sudlitz

1. In 2002 the following ion beams were produced using ECR ion source and provided to the cyclotron:

Ion	Ar^{+6}	Ar^{+7}	$^{11}B^{+2}$	F^{+4}	Ne^{+4}	Ne^{+5}	N^{+3}	O^{+4}	S^{+5}	S^{+7}
Ion current on the inflector [eμA]	29	40	17	55	88	37	115	54	33	42

The beam stability is very high - intensity fluctuations are in the order of 2%. Ions of B and F are especially difficult to obtain, but also for these beams the stability and intensity was satisfying.

2. The ion source has been adapted to work with a higher extraction voltage - up to 15 kV – by improving the insulation. Now the extraction voltage 11 kV (instead of 10 kV) is used.

3. The control of oil cooling the hexapole magnet has been introduced, worn elements of cooling system have been replaced.

4. The damaged cryogenic pump has been replaced, but the new one has been working properly only for 4 months.

3. Studies of the ECR ion source extraction system

K. Sudlitz, E. Kulczycka, A. Górecki, B. Filipiak

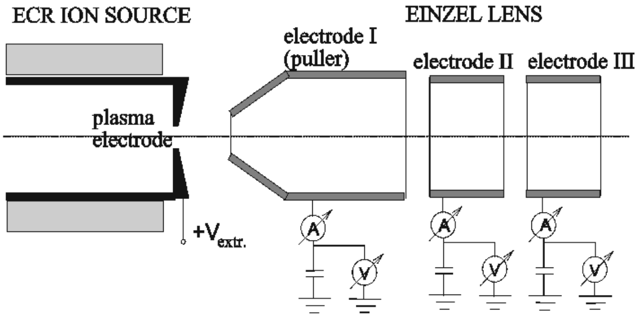


Fig.1 Extraction system of the Warsaw ECR ion source.

Some observations concerning the extraction system (Fig.1) were done during generation of ion beams of O, N, B and Ne:
- there is a strong dependence between ion beam current and Einzel lens voltage (Fig.2). The influence of this voltage is much stronger than one can estimate using electron optics rules
- the change of ion beam current with Einzel lens voltage is discrete. During the beam "breaking" (when decreasing Einzel lens voltage) observed on the wire detector beam profile does not change – so this is not caused by optical divergence
- this phenomenon is stronger for lower charge states (the relative loss of the ion beam current is more rapid) for all the ion beams listed above, but does not occur for hydrogen. The hydrogen beam current was changed only for few percents when decreasing the Einzel lens voltage, but the beam was not "broken" (Fig.3)
- this effect is stronger for worse vacuum, so probably it is related to the impurity level.

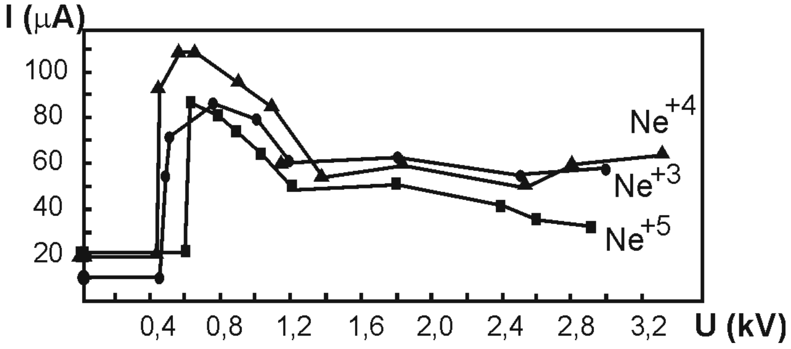


Fig.2. Ion beam current versus Einzel lens voltage.

The ion source performance depends on plasma conditions, but also on extraction system. We think that the influence of the extraction system on the ion beam cannot be explained by one-particle model. In our opinion the observed phenomenon is caused by residual plasma discharge generated in the system, resulting in the increase of the extraction efficiency.

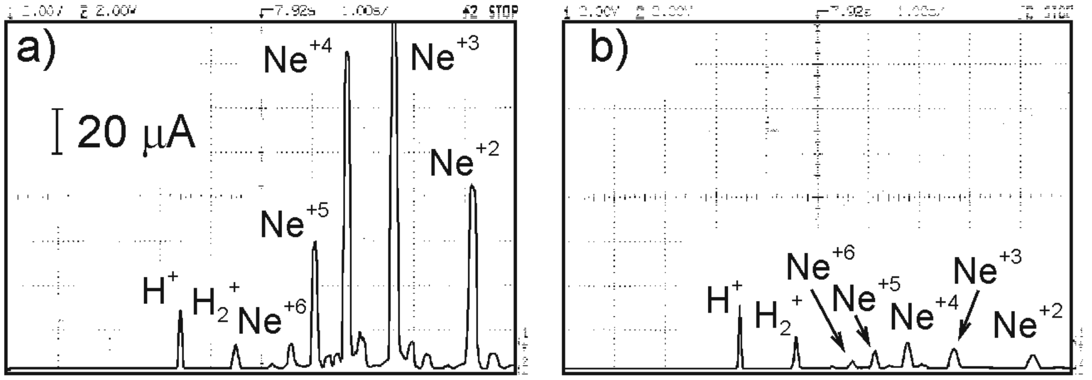


Fig.3. Ne beam spectrum: a) Einzel lens voltage 770 V b) Einzel lens voltage 640 V

Additional remarks:
- a voltage of a few tenths Volts on electrode I or III (Fig.1) decreases the ion beam current from few percent up to 40%. The better the vacuum and the higher charge state, the weaker effect is observed. The influence of the electrode III on the ion beam current is stronger than that of the I-st one. Such a strong effect caused by low voltage cannot be explained by improvement of optical properties of the extraction system.
- a gas mixing effect occurs when adding the buffering gas not only to the plasma chamber, but also to the extraction chamber. Probably this effect is related to vacuum level in the extraction chamber.

4. Amplitude and Phase Regulation of the RF Cavities

J.Miszczak, Z.Kruszyński, M.Sobolewski, B.Daniel

Until the end of year 2002 the cyclotron's main RF cavities operated in open loop mode i.e. without circuitry comparing the dee voltage with the desired value and making a correction accordingly. In order to improve performance of the cyclotron it was decided to build two amplitude control loops (one for each of the resonators) and one phase loop. The loops are analog, with a computer controlling the setpoints, loop mode, and reading back values for display for the operator.

The amplitude loop is pretty straightforward with a peak detector, a PID regulator, and an amplitude modulator. The amplitude detectors operate with large input signals, so with the use of germanium diodes, there is no problem with nonlinearity of the diodes. The PID regulators are really a PI, in order to decrease the burden placed on the RF amplifiers during RF-on transients. The loop gain K, and Ti time constant are set in hardware. The amplitude modulators are build with the EL4094 chips from Elantec company. They are sold as "video gain control/faders" for use in TV broadcast circuits, but they make very good and inexpensive amplitude modulators usable from DC to 20MHz.

The main design challenge was the phase loop. It has to operate with RF frequencies spanning from 12.5MHz to 19.5MHz, which makes it difficult to build a linear phase modulator, and a pulsed mode requires a phase detector capable of dealing with RF-off periods.

The design of the phase modulator builds upon an idea of “phase sequencing network”. This is a network of resistors and capacitors, which outputs a set of quadrature signals when fed with phase and anti-phase input signal, with only minimal phase error over wide span of input frequencies . The quadrature signals are combined in an I/Q type of modulator, which is followed by an AGC stage so only phase modulation remains. The output of the modulator are two RF signals - one is the reference (to resonator A), and the second can be shifted by +/- 40 degrees with respect to the reference.

The phase detector is classic, with the monolithic MC12040 ECL phase-frequency detector from Motorola. When the RF is off and during RF-on transients the phase detector is switched off the loop. This prevents false phase readings reach the phase PID regulator. As with amplitude loop, regulator's parameters are set in hardware.

The amplitude and phase control loops were successfully commissioned in the very beginning of 2003. It was observed almost immediately that the loops significantly improved intensity and stability of the beam.

5. Beam energy measurement using the time-of-flight method

M. Sobolewski, J. Miszczak, J. Sura

The time-of-flight (TOF) system of beam energy measurement, presented in the HIL Annual Report 2001, has been completed and routinely used. Three cylindrical pick-up probes were installed in the C2 beam line. The probes have the inner diameter of 58mm and the length 30mm, except for the N1, which is only 15mm long (for spill beam reason). The probes are shielded by diaphragms of diameter 52mm. The bases between probes are equal: between N1and N2 - 2.7375m and between N2 and N3 - 6.5300m. The probes N1 and N2 are being used to rough estimate of the beam energy in the common line of the beam garden. The N2,N3 are used to precise energy measurement in the beam line C2. The clock-like signals induced by the beam bunches are amplified by 100dB and afterwards differentiated. The time of flight is measured between the zero-points of the differentiated clock-like pulses using the digital Tektronix TDS 640A oscilloscope (with time resolution of 50ps).

The minimum average beam current, which can be measured with reasonable signal-to-noise ratio is around 50nA. The accuracy of medium energy determination proved to be better than 0.5%. This value has been checked in numerous experiments, where the energy could be independently measured (e.g. with beams of ions: $^{14}N^{3+}$, $^{20}Ne^{3+}$, $^{20}Ne^{4+}$, $^{40}Ar^{7+}$, $^{19}F^{4+}$).

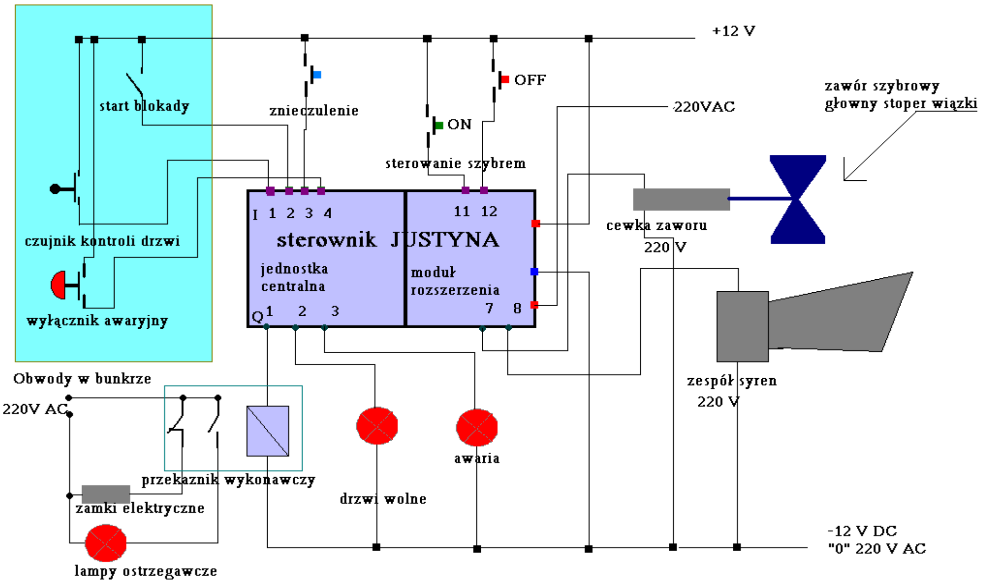
A detailed description of the HIL TOF system is given in an internal report (in preparation).

6. A new radiological safety interlock system

T.Bracha

No accelerator facility in the world can operate without radiological safety interlock system. Detailed operation of such a system is a subject of national and international regulations. The Warsaw cyclotron operated with a custom made, relay based, interlock system. The system was inflexible and rather inconvenient to use. It was decided to replace the interlock system with a new, programmable one. The new system was designed and built in-house, using PLC controllers manufactured by Siemens. The control program for the PLC was developed and tested on a PC computer and then downloaded to the PLC. The development environment called LEGO is very easy to use, with nice graphic user interface.

The new control unit is located in the cyclotron's main control room, and is connected to limit switches, indicator lamps, panic buttons etc. located elsewhere in the cyclotron building. It was possible to re-use most of the field wiring from the old system to connect the control unit to the peripheral devices. The schematic diagram of the system is shown below.



7. The activity of the electric support group

J. Kurzyński, S. Dawidowicz, V. Khrabrov, M. Kopka, P. Krysiak, K. Łabęda, Z. Morozowicz, K. Pietrzak

1. Modification of the design and modernization of the 1300A DC power supply for the main coils of the cyclotron magnet. This task included: (a) Automatic safeguarding against cooling water overheating; (b) Detecting the loss of cooling water; (c) Cooling water pressure fluctuations; (d) Main power breakdowns; (e) Imbalance or lack of the phases from the outside sources; (f)Malfunction of the thyristor branch safety switch. The details of all this works can be found in the HIL Internal Report 2/2002

2. Changes in the construction and the regulation mode of the 60kWstabilized power supply used for the feeding of the switching magnets on the beam lines. This power supply was constructed in in 1990's and required deeply reaching modernization: (a) Current stabilization replaced from existing current-voltage transductor to LEM, which made necessary to replace the difference amplifier; (b) The control of the thyristor ignition angle was modernized; (c) The supply was safeguarded against the main power breakdown; (d) Transistor branches were made insensitive to the possible main power voltage fluctuations. The details can be found in the HIL Internal Report 3/2002

3. Redaction of the Polish version of original documentation of the quadrupole power supplies (Russian). Documentation of the block schemes of the power supplies - partly translation from Russian, otherwise supplemented by the description of modifications with respect to the original design. This work was intended to facilitate operations, conservation and repairs by the cyclotron crew. HIL Internal Reports 4/2002 and 5/2002

4. Design of the computer-controlled systems for the power supplies - switching magnets and ion beam optics - to create an user-friendly system operable from the control room.

5. Routine conservation and adjustments of all power supplies.

Part B:

Experiments
and experimental set-ups

1. Electromagnetic properties of ^{165}Ho inferred from Coulomb excitation

J. Iwanicki, M. Zielińska[1,2], *T. Czosnyka, J. Choiński, P. Napiorkowski, M. Loewe*[3], *M. Würkner*[3], *J. Srebrny*[2]

1) PhD student at HIL
2) Institute of Experimental Physics, Warsaw University, Poland
3) Department of Physics, Ludwig-Maximilians University Munich, Garching, Germany

The existence of associated highly collective γ-bands makes the ^{165}Ho nucleus an ideal candidate to probe the relevance of K quantum number. The motivation of this work was to ascertain whether or not the orientation of K spin projection influences the internal structure of the nucleus using a model-independent method. A measurement of the electromagnetic matrix elements is one of the best methods to study such a problem.

A set of three experiments with 50 MeV ^{20}Ne, 130 MeV ^{40}Ar and 55 MeV ^{16}O beams from Warsaw Cyclotron was performed. Experiments with ^{20}Ne and ^{40}Ar beams were performed using **CUDAC** as a particle detector for particle-γ coincidence. During the experiment with ^{40}Ar beam an inclusive energy spectrum was collected in parallel to get additional Coulex information. The experiment with the oxygen beam was performed with the **OSIRIS** array, without detecting scattered particles.

The simplified ^{165}Ho level scheme is shown on Figure 1. The transitions observed in the experiments are marked with arrows.

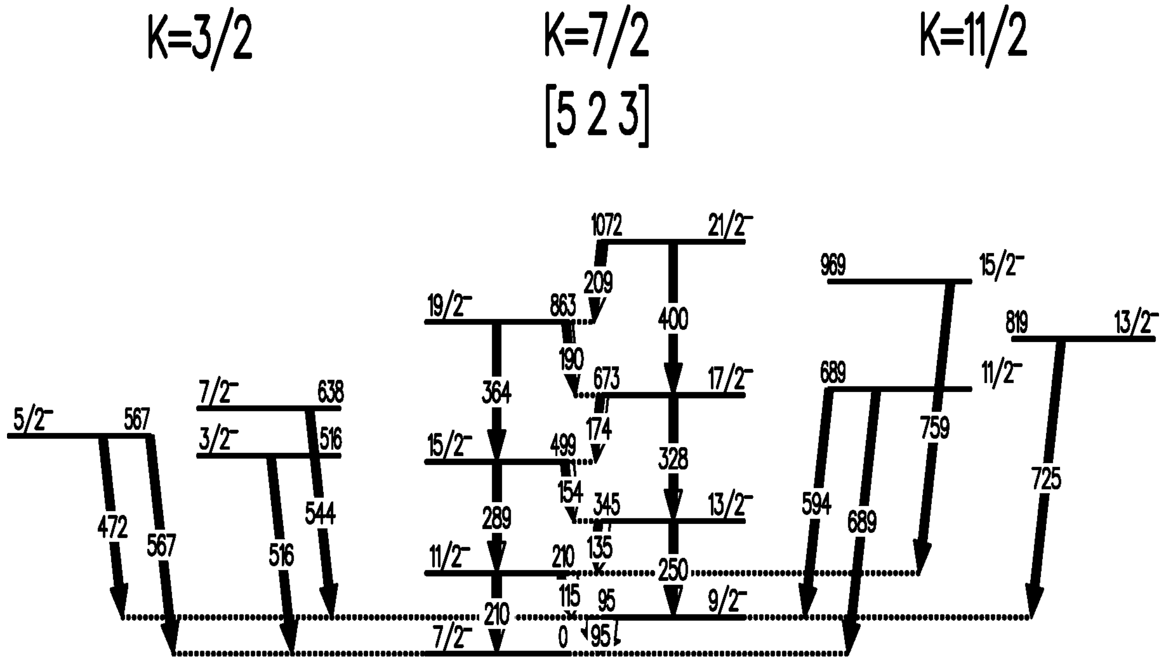


Fig.1. Low-lying excited states of the ^{165}Ho nucleus.

A model-independent analysis using the GOSIA code yielded a set of 26 reduced E2 matrix elements and 12 M1 matrix elements coupling the 13 low-lying excited states. A quadrupole sum rules approach was used to determine the deformation of the states.

Figure 2 shows the expectation values of the $\langle Q^2 \rangle$ invariant, calculated for chosen states in different bands of the ^{165}Ho nucleus.

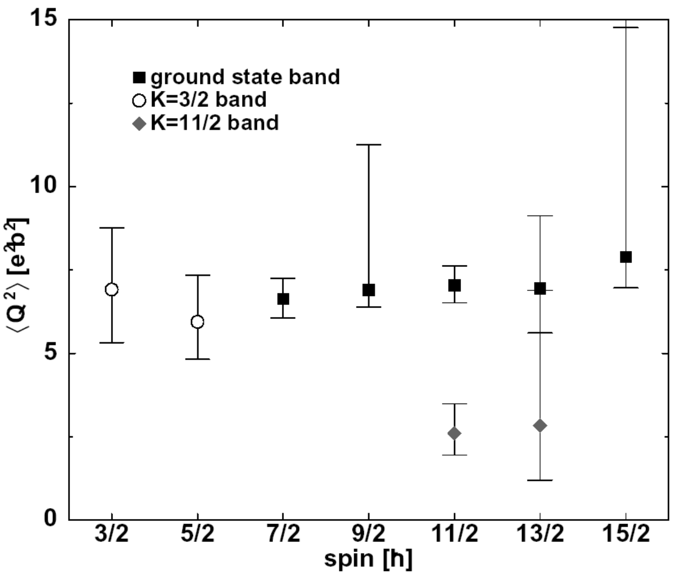


Fig.2. $\langle Q^2 \rangle$ values determined for chosen states in the ^{165}Ho nucleus.

The $\langle Q^2 \rangle$ value is almost constant for the ground state (K=7/2) band members and for the K=3/2 band levels. For the lowest states in the K=11/2 rotational band it is almost two times smaller than those for K=7/2 and K=3/2 bands.

More detailed description of the results is presented in J. Phys. ***G29****, (2003) 743.*

2. Coulomb excitation of ^{96}Mo

M. Zielińska[1,2], *J. Choiński, T. Czosnyka, J. Iwanicki, P. Napiorkowski, J. Srebrny*[2]

1) PhD student at HIL
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The experiment of Coulomb excitation of ^{96}Mo with ^{40}Ar beam of energy 100 MeV, performed in May 2002 at HIL, was a part of a bigger project intended to examine the systematics of the shape evolution in Mo isotopes. The electromagnetic structure of ^{98}Mo has been already studied using the Coulomb excitation method [1,2] The results clearly show the shape coexistence - the ground state is triaxial, while the first excited 0^+ level is prolate. The first evaluation of the results points out to the effect of proton-neutron pairing, up to now estimated to be important only for N=Z nuclei [3]. The confirmation of this suggestion requires that the data on the structure of neighbouring nuclei are established.

To obtain a rich and precise set of reduced matrix elements for ^{96}Mo nucleus, which is necessary to explain the nature of the first excited state in ^{98}Mo, a set of experiments using different beams has to be performed. The experiment ^{40}Ar + ^{96}Mo was the first in a planned series, the next ones are ^{20}Ne + ^{96}Mo (also at HIL), ^{48}Ti + ^{96}Mo (New Delhi, in framework of the Polish-Indian joint project) and finally ^{136}Xe + ^{96}Mo (JAERI, Tokai).

References

[1] M. Zielińska *et al.*, Acta Phys. Pol. **B33** (2002) 515.
[2] M. Zielińska *et al.*, Nucl. Phys **A712** (2002) 3.
[3] K. Zając, Acta Phys. Pol. **B,** to be published.

3. In-beam spectroscopy of nuclei produced in the ^{98}Mo(^{16}O,*x*n) reaction

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Spectroscopic studies have been performed in the region of the neutron deficient Sn nuclei with the aim to gather more information on the intruder bands and their systematical behavior as well as to resolve some ambiguities concerning the level schemes construction. Near the shell closure one can expect strong interference of single-particle and collective effects leading e.g. to the shape coexistence. One particular possibility for shape coexistence is associated with the occurrence of intruder states. In the odd nuclei intruder single-particle states originate in most cases from the next higher shell. In even nuclei intruder states are associated with the excitation of one or two particles into the next shell [1]. Proton particle-hole excitations across the Z=50 gap are responsible for low-lying deformed states, which result in collective rotational bands. The rotational bands have been interpreted as being built on a two-particle two-hole (*2p-2h*) configuration. The low spin states in ^{110}Sn have previously been investigated in the decay of the ground state of ^{110}Sb [2] as well as in the number of reaction studies [3]. The existence of $I^{\pi}=6^{+}$, $T_{1/2}$=5.6 ns isomer decaying by the 280 keV, 985 keV and 1212 keV γ cascade to the ground state was well established. Rotational bands have been observed in $^{116-118}$Sn even-mass nuclei down to the 0^{+} band head [4] (which is located at an energy of about 2 MeV), whereas, in ^{110}Sn [3,5] and ^{112}Sn [5] no intruder band members below spin 10 have been observed prior to this work.

The experiment was performed at the Heavy Ion Laboratory of the Warsaw University with the OSIRIS-II detector array. A beam of ^{16}O bombarded a ^{98}Mo (5.6 mg/cm^2) target, leading to the compound nucleus ^{114}Sn. This reaction was investigated at four beam energies: 60, 70, 75 and 80 MeV. In all experiments OSIRIS-II was equipped with 10 HPGe Compton suppressed spectrometers combined with 48-element BGO multiplicity filter. The HPGe's were surrounding the filter, about 17 cm from the target and the BGO crystals served as collimators for the Ge detectors. Events were accepted by the data acquisition system if at least two coincident γ rays were detected in the Ge detectors. A total amount of 8×10^{7} $\gamma\gamma$-coincidence events was recorded in the coincidence experiment. The compound nucleus ^{114}Sn was favouring the evaporation of neutrons, hence the main reaction products were ^{110}Sn (*4n*), ^{111}Sn (*3n*) and ^{112}Sn (*2n*).

Our experiment has confirmed levels reported previously for ^{110}Sn, ^{111}Sn and ^{112}Sn [3, 5, 6], and several new levels were identified. In the level scheme of ^{110}Sn we proposed four new side bands (including M1-transition band). Moreover, the negative parity band was extended. For ^{111}Sn one of the bands was extended. Complete level schemes for ^{110}Sn, ^{111}Sn and ^{112}Sn will be published elsewhere [7]. Here, we present partial level schemes of ^{110}Sn, ^{111}Sn and ^{112}Sn relevant for the discussion of the intruder bands, see Fig.1. These are positive parity bands in ^{110}Sn and ^{112}Sn, and negative parity band in ^{111}Sn. The ordering of transitions is based on relative γ-ray intensities and coincidence relationships. The intensity of transitions were determined using ESCL8R program [8]. Analysis of these data enabled a detailed level scheme to be established for the lower-spin states in intruder band (below the 5228 keV state) of ^{110}Sn. The level having an excitation energy of 5018 keV, intepreted as $I^{\pi}=10^{+}$ state was observed for the first time in this work. The new levels proposed for ^{110}Sn are in agreement with the level systematics of corresponding states in neighbouring even-Sn nuclei. The level energies of states in the intruder band increase with decreasing neutron number [9]. The new γ-transitions suggesting the existence of a neutron-core coupling in ^{111}Sn are not included in the presented part of the level scheme. For ^{112}Sn the lower part of intruder band was extended too (below the 2785 keV state).

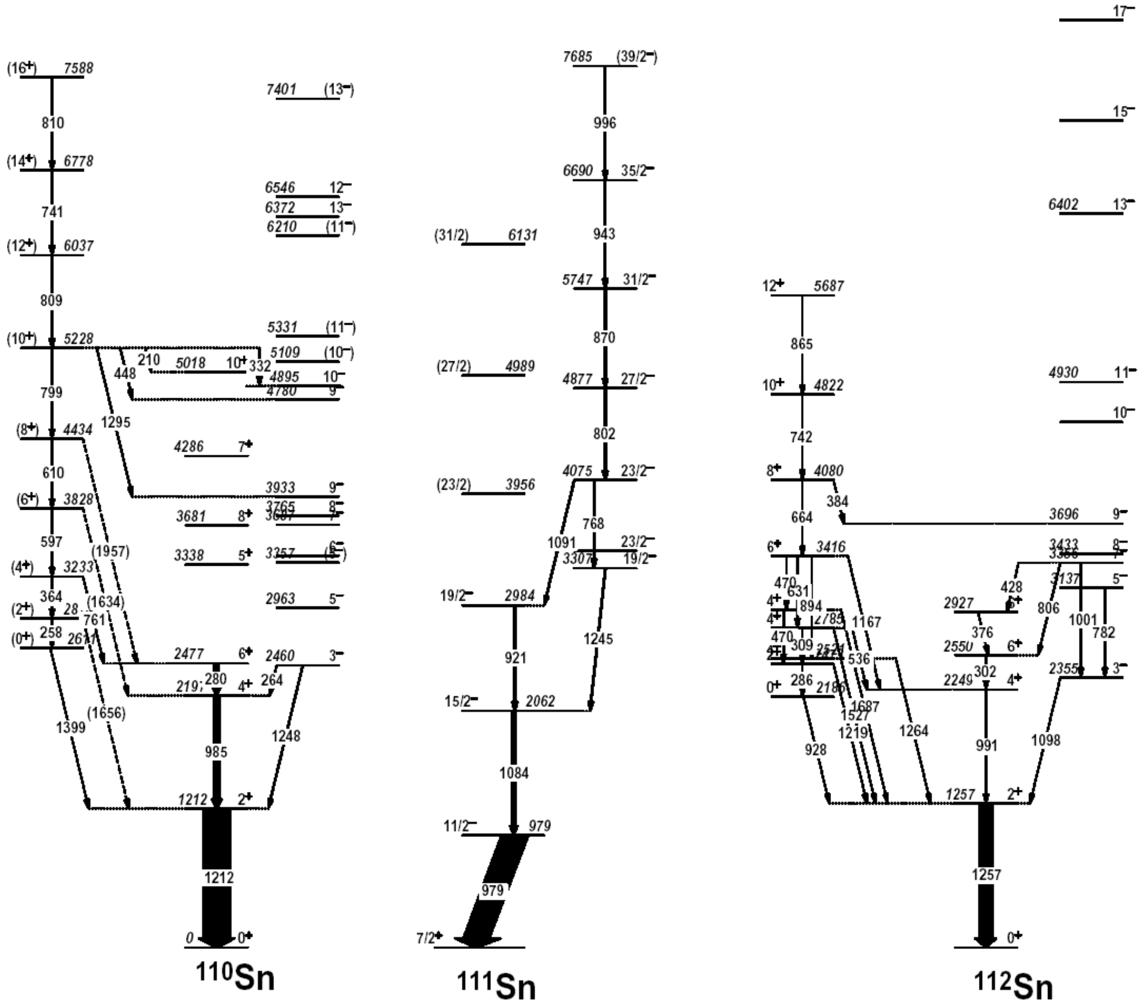

Fig. 1: Partial level schemes limited to the intruder bands: positive parity band in ^{110}Sn and ^{112}Sn, and negative parity band in ^{111}Sn. Gamma-ray energies are given in keV.

In conclusion, we have observed new levels and transitions in the neutron deficient nuclei ^{110}Sn, ^{111}Sn and ^{112}Sn, including the extention of the intruder bands. The second 10^+ state found in ^{110}Sn is consistent with systematical behaviour of even-Sn isotopes. A short discusion of the experimental results concerning the collective states and band-like structures is presented in the other contribution to this report [10].

References

[1] K. Heyde *et al.*, *Phys. Rep.* **102**, 291 (1983.)
[2] M. Singh *et al.*, *Nucl. Phys.* **A193**, 449 (1972).
[3] D.A. Viggars *et al.*, *Phys. Rev.* **C36**, 1006 (1987).
[4] J. Bron *et al.*, *Nucl. Phys.* **A318**, 335 (1979).
[5] H. Harada *et al.*, *Phys. Let.* **B207**, 17 (1988).
[6] D.R. LaFosse *et al.*, *Phys. Rev.* **C51**, R2876 (1995).
[7] M. Wolińska-Cichocka *et al.*, to be published and PhD thesis, in preparation.
[8] D.C. Radford, *Nucl. Inst. Meth.* **A361**, 290 (1995).
[9] S. Juutinen *et al.*, *Nucl. Phys.* **A617**, 74 (1997).
[10] M. Wolińska-Cichocka *et al.*, contribution to this report.

4. Variety of band structures in light Sn, In, and Cd nuclei

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The available experimental spectroscopic data for light Sn, e.g.[1, 2], In [3, 4] and Cd [5, 6] nuclei make possible to trace systematic behaviour of band structures and shape competition in these nuclei. Also convincing theoretical arguments for the existence of the intruder bands in the low spin states region of these nuclei have been presented [7, 8, 9, 10]. In the even-A, $_{50}$Sn nuclei these bands are thought to be built on the proton 2p-2h excitations $(\pi g_{7/2})^2\otimes(\pi g_{9/2})$ and $\pi(g_{9/2}^{-2}\otimes g_{7/2}^{1}h_{11/2}^{1})$ leading to the deformed shapes observed in $^{108\text{-}118}$Sn. The odd-mass Sn nuclei are believed to have rotational bands constructed on the valence neutron occupying the $\nu g_{7/2}$, $\nu d_{5/2}$ and $\nu h_{11/2}$ orbitals, coupled to the 2p-2h intruder states in even-Sn nuclei. In the Cd nuclei, having 2 protons less, the picture is not so clear, however, the evidence for the existence of proton intruder structures was found [5, 11, 12]. The role of protons in these states is not yet fully understood. As an example, the moments of inertia of the intruder bands in the Sn nuclei are significantly larger than in the corresponding bands in the Cd isotopes. As for the ^{111}In nucleus the proton intruder band reported in ref. [13] was not confirmed in the present investigation. In this contribution, selected spectroscopic results of experimental studies concerning the region of considered nuclei carried out within OSIRIS-II collaboration at the Heavy Ion Laboratory of the Warsaw University are revealed.

B(E2) branching ratios of (intruder-to-intruder)/(intruder-to-yrast) transitions.
The properties of excited states in ^{110}Sn, ^{111}Sn and ^{112}Sn were studied with a special interest put on the observation of intruder bands especially at low spins, where no band members were until now observed [14]. A comparison of the experimentally obtained $B(E2)_{intruder}/B(E2)_{yrast}$ ratios of E2 transition probabilities for light Sn nuclei is given in Table 1. In spite of the fact that light Sn, In and Cd nuclei are far from being good rotors, one can also follow the common way to use the terms of the CSM [15] to facilitate the discussion of the band structure.

Table 1. *Experimental B(E2), γ-ray branching ratios (λ) in light Sn isotopes. Subscripts 'i' and 'y' denote intruder and yrast, respectively.*

Nucleus	E_γ (keV)	I_i	I_f	I_γ	λ	$R_{exp} = \frac{B(E2)_{in}}{B(E2)_y}$	$\frac{R_{exp}}{R_{calc}}$
^{110}Sn	368	$(4^+)_i$	$(2^+)_i$	0,07±0,03	3,5±1,5	$1{,}7*10^5$	≥0,98
	2017	$(4^+)_i$	$(2^+)_y$	≤0,02			
	597	$(6^+)_i$	$(4^+)_i$	3,0±0,21	30±20	≥4545	≥0,92
	1627	$(6^+)_i$	$(4^+)_y$	≤0,1			
	610	$(8^+)_i$	$(6^+)_i$	0,7±0,03	14±6	≥4745	≥0,96
	1956	$(8^+)_i$	$(6^+)_y$	≤0,05			
	799	$(10^+)_i$	$(8^+)_i$	0,48±0,04	2,9±0,6	5,6±1,2	0,99
	912	$(10^+)_i$	$(8^+)_y$	0,16±0,03			
	808	$(12^+)_i$	$(10^+)_i$	2,89±0,14	24±8	76±25	0,98
	1019	$(12^+)_i$	$(10^+)_y$	0,12±0,04			

Nucleus	E_γ (keV)	I_i	I_f	I_γ	λ	$R_{exp}=\frac{B(E2)_{in}}{B(E2)_y}$	$\frac{R_{exp}}{R_{calc}}$
^{111}Sn	769	$(23/2^-)_i$	$(19/2^-)_i$	1,66±0,10	1,0±0,1	6,0±0,5	0,91
	1092	$(23/2^-)_i$	$(19/2^-)_y$	1,61±0,10			
	769	$(23/2^-)_i$	$(19/2^-)_i$	1,66±0,10	2,3±0,3	6,7±0,8	0,95
	952	$(23/2^-)_i$	$(19/2^-)_y$	0,72±0,07			
	769	$(23/2^-)_i$	$(19/2^-)_i$	1,66±0,10	2,7±0,3	4,4±0,5	0,82
	846	$(23/2^-)_i$	$(19/2^-)_y$	0,61±0,06			
	870	$(31/2^-)_i$	$(27/2^-)_i$	2,55±0,12	4,7±0,5	5,8±0,6	0,92
	907	$(31/2^-)_i$	$(27/2^-)_y$	0,55±0,05			
^{112}Sn	893	$(6^+)_i$	$(4^+)_i$	1,43±0,50	0,4±0,2	1,7±0,7	0,99
	1167	$(6^+)_i$	$(4^+)_y$	3,30±0,82			
	631	$(6^+)_i$	$(4^+)_i$	2,05±0,64	0,6±0,3	13,4±5,3	0,91
	1167	$(12^+)_i$	$(4^+)_y$	3,30±0,82			
	745	$(12^+)_i$	$(10^+)_i$	2,86±0,62	7,8±3,7	19±10	0,99
	888	$(14^+)_i$	$(10^+)_y$	0,36±0,25			
	800	$(14^+)_i$	$(12^+)_i$	5,19±0,81	5,3±2,5	2,4±1,4	0,97
	680	$(14^+)_i$	$(12^+)_y$	0,89±0,25			

The results given in Table 1 show rather strong intraband B(E2) values as compared to reduced interband decays. This indicates that the intruder band structures at the low spins are mixed with the "normal" spherical structures and therefore the intruder bands are perturbed at low spins, contrary to that what is observed at higher spins. In the alignment plot, this mixing would manifests itself as an irregularity at low rotational frequencies. A simple level mixing calculation was performed in order to see if such mixing of states can account for the observed B(E2) γ-ray branching ratios for transitions between mixed yrast and intruder-band states. The values of the mixing amplitudes (91-99%, 10-40%), as well as the interaction energies (58-825 keV), depend on the B(E2) values between unmixed states. As indicated in Table 1, the mixing calculation is able to account for the values of B(E2) ratios of the intruder-to-intruder and intruder-to-yrast transitions. The band crossing in the intruder bands for ^{110}Sn and ^{112}Sn occurs at $\hbar\omega$ =0.37 MeV in ^{110}Sn and ~0.35 MeV in ^{112}Sn while the increase in the alignment is about $7\hbar$ for both of them. In this mass region the first band crossing has usually been attributed to the $h_{11/2}$ neutrons [7, 8]. The intraband B(E2) values in the intruder bands of $^{112, 114, 116, 118}$Sn are also analyzed within the framework of the IBM1 model [16]. A detailed comparison of these bands with the ground state bands in the even-mass Xe isotopes allows [16] to find a similarity for the energy spacings as well as for B(E2) values.

Band termination in the A=104~120 mass region. ΔI=1 bands.

The second irregularity in the alignment plot observed [14] in ^{110}Sn takes place at $\hbar\omega$ ~0.5 MeV and could be tentatively interpreted as a sign of a transition to a terminating band structure. Similar interpretation in terms of smoothly terminating, i.e. where all spin vectors of the particles involved in the configuration are fully aligned, bands based on 2p-2h structures is proposed [17] for ^{108}Sn. The calculations for ^{108}Sn [9] predict that the positive parity $\pi[g_{9/2}^{-2}\otimes(g_{7/2}d_{5/2})^{2}]\otimes\nu[(d_{5/2}g_{7/2})^{6}h_{11/2}^{2}]$ configuration should be crossed by the $\pi[g_{9/2}^{-2}\otimes(g_{7/2}h_{11/2})]\otimes\nu[(d_{5/2}g_{7/2})^{5}h_{11/2}^{3}]$ configuration at spin $32\hbar$, as seen in the experiment. Considering the excitation energies versus spin in terms of E_x-E_{RR}, i.e. with a rigid rotor rotation reference subtracted, the various features can be observed: a) irregularities at low spins of ^{110}Sn and ^{112}Sn associated with spherical structures and very similar behaviour for slightly higher spins, b) the crossing of the negative parity g.s. and intruder bands in ^{111}Sn at a frequency of about 0.45 MeV as well as c) rigid rotation-like behaviour of $\Delta I=1$ band in ^{110}Sn. In ^{111}Sn a band with a smooth termination properties has previously been reported [18] and is confirmed in the present work. In this case, the 2p-2h proton structure $(\pi g_{7/2})^2 \otimes (\pi g_{9/2})^{-2}$ is coupled to an $h_{11/2}$ neutron. Similar structures have also been observed in Te nuclei, where the associated configurations are supposed to involve 4p-2h proton states, as well as in light I isotopes, with 5p-2h proton structures. It was pointed out by I.Ragnarsson [9], that three different scenarios can occur close to the termination point when the excitation energies are plotted relative to energy of rigid rotation, namely for some bands the E-E_{RR} differences are essentially constant (rigid rotation like), while other slope upwards (unfavoured) or downwards (favoured) before termination. When comparing the behaviour of experimentally observed bands in the rigid rotor reference frame (Figs. 1, 2) it is evident that there are examples of unfavoured and rigid rotation like termination. A group of decay sequences in ^{106,108,110}Sn, ^{104,106}In and ^{110}Cd with many common characteristics which distinguish them from normal collective rotational bands is shown in Fig.2. All of these sequences start above 3 MeV excitation energy and decay predominantly via $\Delta I=1$, similarly to oblate M1 bands in Ba and Pb region or to prolate M1 band proposed in ^{108}Cd [19]. Spins of their band heads are usually greater than $12\hbar$ and their parities are most likely negative. Energy spacings within those bands are smaller than for the other observed bands at similar energies. The strongly coupled bands, observed both in ^{106}Sn and ^{108}Sn and now also in ^{110}Sn most likely involve the proton $g_{7/2}g_{9/2}^{-1}$ particle-hole excitation coupled to the neutrons above the N=50 shell gap. Since the parity of levels belonging to these sequences is most likely negative, one can propose the $\pi\, g_{7/2}g_{9/2}^{-1}\nu(g_{7/2})^5 h_{11/2}$ configuration. The energy difference between strongly coupled bands in ^{106}Sn and ^{108}Sn is similar to the energy difference for the 9^- states ($\nu g_{7/2}h_{11/2}$) in those nuclei, which supports proposed configuration assignment. The bands are expected to terminate at spin 25^-. Bands characterized by strong dipole transitions have also been observed in ^{114}Sn, ^{115}Sn and ^{105,107,109}In nuclei, as well as Sb, Te and I nuclei. Common to these bands is that their configurations involve a proton 1p-1h excitation where a hole is in the proton $g_{9/2}$ orbital and the particle in one of the downsloping orbitals from above the Z=50 gap. The $\Delta I=1$ sequences considered here share many properties of the collectively rotating bands in the A~80, A~ 130 regions, and the "shears bands" in the Pb region. A general question may appear, if the observed $\Delta I=1$ sequences are a manifestation of the magnetic rotation [20] being also a special case of band termination?

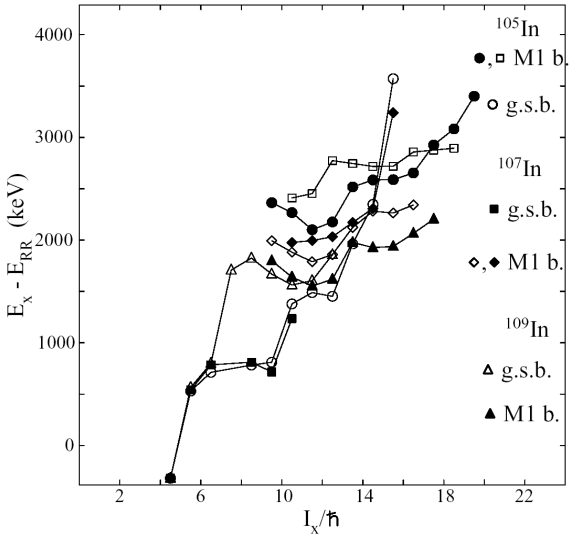

Fig. 1: Excitation energy relative to an I(I+1) rigid rotor reference as a function of spin for $\Delta I=1$ bands in light odd-A In isotopes [4]. A comparison with g.s.b. dependence is also shown.

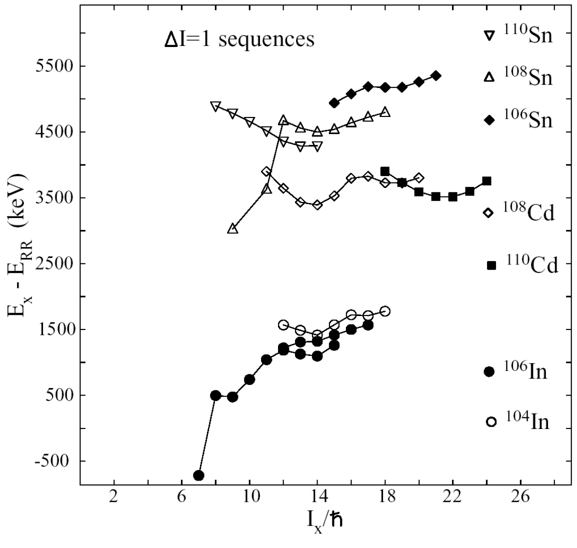

Fig. 2: Excitation energy relative to a rigid rotor reference plotted as function of I_x for the $\Delta I=1$ bands in ^{108,110}Cd [5, 19], ^{104,106}In [3], ^{106,108}Sn [5] and ^{110}Sn [14] nuclei.

Conclusions*:* A variety of collective states forming rotational bands and band-like structures is considered with a special emphasis put on: (a) mixing of the low spin states of the intruder bands with states of the spherical origin, (b) the $\Delta I=1$ negative parity sequences in the $A\sim110$ (neutron deficient) region and (c) the band termination phenomenon in nuclei of close neighborhood to the ^{114}Sn core.

References

[1] M. Singh *et al.*, *Nucl. Phys.* **A193**, 449 (1972).
[2] J. Bron *et al.*, *Nucl. Phys.* **A318**, 335 (1979).
[3] D. Seweryniak *et al.*, *Nucl. Phys.* **A589**, 175 (1995).
[4] J. Kownacki *et al.*, *Nucl. Phys.* **A627**, 239 (1997).
[5] S. Juutinen *et al.*, *Nucl. Phys.* **A573**, 306 (1994) and **A617**, 74 (1997).
[6] D. Jerrestam *et al.*, *Nucl. Phys.***A593**, 162 (1995) and **A545**, 835 (1992).
[7] K. Heyde *et al.*, *Phys. Rev.* **C37**, 2170 (1988), CERN-EP **98-181**, 1 (1998).
[8] J.L. Wood *et al.*, *Phys. Repts.* **215**, 101 (1992).
[9] I. Ragnarsson *et al.*, *Acta Phys. Pol.* ***B32***, 2597 (2001), *Phys. Rev. Lett.* **74**, 3935 (1995).
[10] H.W. Fielding *et al.*, *Nucl. Phys.* **A281**, 389 (1977).
[11] R.A. Meyer *et al.*, *Z. Phys.* **A283**, 379 (1977).
[12] M. Deleze *et al.*, *Nucl. Phys.* **A551**, 269 (1993).
[13] S.M. Mullins *et al.*, *Phys. Lett.* **B318**, 592 (1993).
[14] M. Wolińska-Cichocka *et al.* - contribution to this report and to be published.
[15] R. Bengtsson and S. Frauendorf, *Nucl. Phys.* **A314**, 27 (1979) and **A327**, 139 (1979).
[16] A.A. Pasternak - priv. com. and A.D. Efimov *et al.* - to be published.
[17] R. Wadsworth *et al.*, *Phys. Rev.* **C53**, 2763 (1996).
[18] D.R. LaFosse *et al.*, *Phys. Rev.* **C51**, R2876 (1995).
[19] I. Thorslund, PhD thesis, (1993).
[20] S. Frauendorf, *Rev. Mod. Phys.* **73**, 463 (2001).

5. Lifetime Measurements of High-spin States in ^{132}La using the DSA Method

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Recent theoretical [1,2,3] and experimental (see e.g. [3,4]) works have attracted attention to the problem of chirality in atomic nuclei with odd numbers of protons and neutrons. In this case the total nuclear spin is composed of the valence proton and valence neutron momenta and angular momentum of the even-even core. For some conditions (see e.g. [3]), fulfilled for nuclei from the A $\approx$130 mass region, these three vectors can be mutually perpendicular and coupled in two manners forming systems (left- and right-handed) with opposite chirality in the intrinsic frame of nucleus. In the laboratory frame it manifests itself as the presence of two rotational bands with nearly degenerated level energies and with the same parities. Such bands based on the $\pi h_{11/2}*\nu h_{11/2}$ configuration have been found in ^{132}La and interpreted [3] as manifestation of chirality in the angular momentum coupling.

The study of the chiral twin bands is in its early stage. For example, no data on the lifetimes of members the chiral rotational bands are available, despite the fact, that such data carry significant information on nuclear wave functions.

High-spin excited states in ^{132}La were populated in the ^{122}Sn(^{14}N,4n)^{132}La reaction at a beam energy of 70 MeV. The beam was provided by the Warsaw U200P cyclotron. The ^{122}Sn target was 10 mg/cm^2 thick. The lifetimes of the excited states in ^{132}La were measured using the Doppler Shift Attenuation method. Data were sorted off-line into several $\gamma-\gamma$ matrices containing events from a specified detector on one axis, and events from all remaining detectors on the second. The matrices were used for lifetime evaluation. Lifetimes of four levels, belonging to the yrast band based on the $\pi h_{11/2} * \nu_{11/2}$ configuration, were determined from the preliminary γ–line shape analysis. For levels with spin $I^\pi = 20^+, 19^+, 18^+, 17^+$ the lifetimes are equal to 1.3, 0.8, 0.6, 0.6 ps, respectively. The further analysis is in progress.

References:

[1] S. Frauendorf and J. Meng, Nucl.Phys. **A617**(1997)131
[2] V.I. Dimitriv et al., Phys.Rev.Letter **84**(2000) 5732
[3] K.Starosta et al., Phys. Rev. **C65**(2002)044328
[4] K.Starosta et al., Phys. Rev. Letters **86**(2001) 971

6. The (^{11}B,X) and (^{14}N,X) reactions on the targets ^{6}Li, ^{7}Li, ^{12}C

A.T. Rudchik[1], V.K. Chernievsky[1], A.A. Rudchik[1], A. Budzanowski[2], J. Choiński, T. Czosnyka, L. Głowacka[4], S. Kliczewski[2], E.I. Koshchy[5], G.M. Kozeratska[1], S.Yu. Mezhevych[1,3], K. Rusek[3], R. Siudak[2], I. Skwirczyńska[2], A. Szczurek[2], L. Zemło

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The angular distributions of the ^{6}Li(^{11}B,X), ^{7}Li(^{11}B,X), ^{12}C(^{11}B,X), ^{6}Li(^{14}N,X), ^{7}Li(^{14}N,X) and ^{12}C(^{14}N,X) reactions were measured using the Warsaw cyclotron U-200P at the beam energies $E_{lab}(^{11}\mathrm{B}) = 50$ MeV and $E_{lab}(^{14}\mathrm{N}) \approx 80$ MeV. The experiment was performed to study the reaction mechanisms and to search for the new ^{6}Li and ^{6}He levels predicted by some models. No experimental data were known from the literature for the most of the reactions measured in given experiment.

The standard electronics of CAMAC type, SMAN acquisition system and ΔE-E spectrometers with the ionization chamber + silicon detector and silicon - silicon detectors were used in the experiment. The spectrometer with the silicon ΔE-detector was used to detect the light particles.

Argon was used as a working gas in the ionization chamber. The self-supporting ~700 μg/cm^2 ^{6}Li (~90% enrichment), ^{7}Li (natural enrichment) and 200 μg/cm^2 ^{12}C foils were used as targets. No significant contaminations of other elements in the targets were observed.

The typical ΔE-E spectra for the ^{7}Li(^{11}B,X) and ^{6}Li(^{14}N,X) reactions are shown in Fig. 1. One can see that the reaction products with the charges of $Z = 3 - 9$ were distinguished.

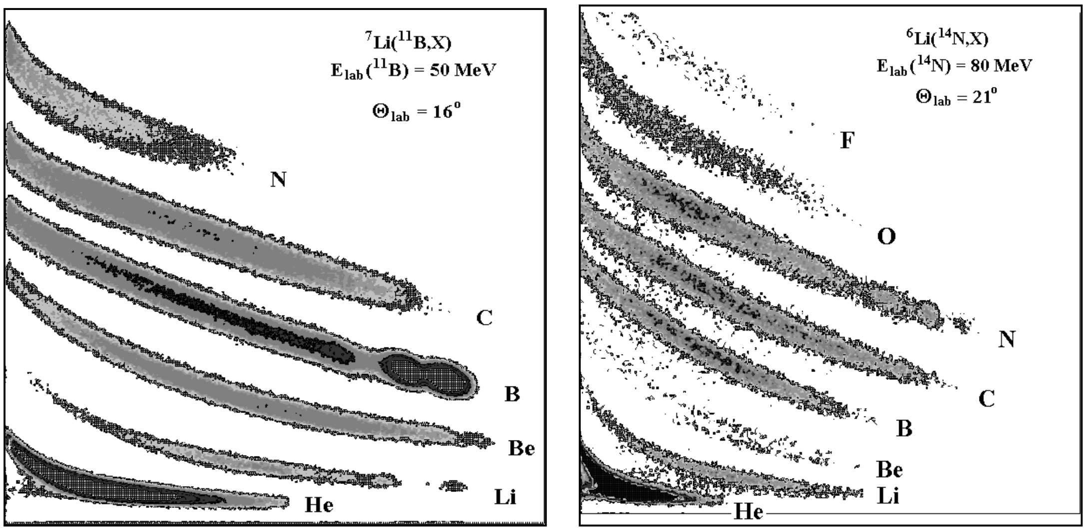

Fig. 1. Typical *ΔE-E* spectra for the ^{7}Li(^{11}B,X) and ^{6}Li(^{14}N,X) reactions.

Fig. 2 shows the energy spectrum of boron isotopes detected at the angle $\theta_{lab} = 10^0$. The residual spectrum obtained after a subtraction of background (dashed curve in upper panel) is shown in the lower panel. The new ^{6}Li levels, close to the ones predicted by the shell model (10.4 MeV (2, T=1), 11.7$^-$MeV (1^-, T=1), 12.9 MeV (0^-, T=1)) [1], are marked in the ^{6}Li level diagram by the arrows and dashed curves of the Gauss functions. It was found that the candidates for the new ^{6}Li states are the levels 8.85 MeV, 10.15 MeV, 11.2 MeV and 12.75 MeV.

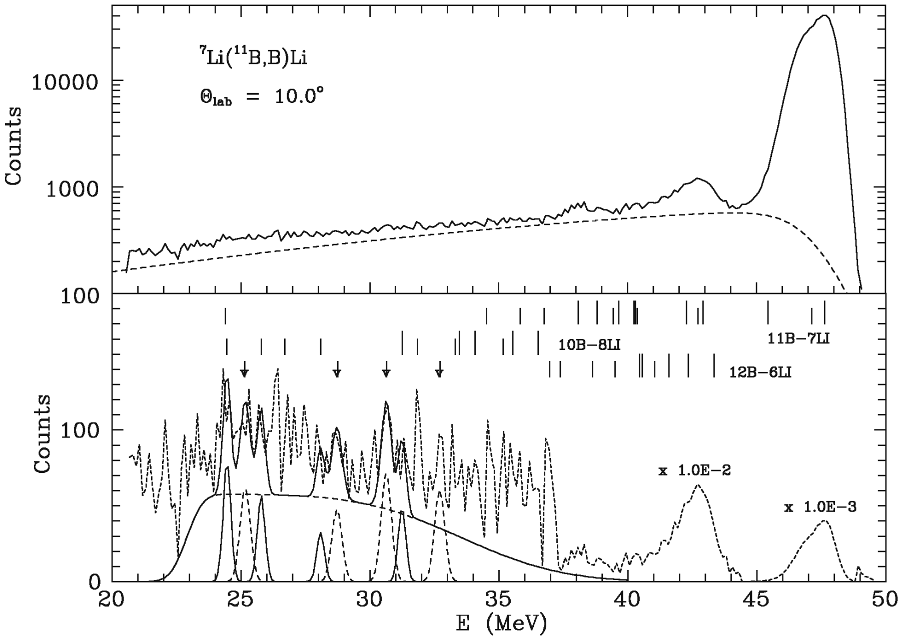

Fig. 2. Energy spectrum of boron isotopes detected at the angle $\theta_{lab} = 10^0$.

References

[1] A.N. Boyarkina, *Structure of 1p-Shell Nuclei*, Moscow State University, 1973.

7. Giant Dipole Radiation and Isospin Purity in Highly Excited ^{32}S Nuclei.

M. Kicińska-Habior[1], E. Wójcik[1], O. Kijewska[1], M. Kisieliński, M. Kowalczyk[1], J. Choiński, A. Kordyasz, W. Czarnacki[2]

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We have made an attempt to determine the degree of isospin mixing in nuclear reactions forming ^{32}S compound nuclei at several excitation energies. For this purpose we have measured γ-ray spectra from the statistical decay of the Giant Dipole Resonance built on excited states formed in heavy-ion fusion reactions. The E1 decays from T=0 to T=0 states are isospin forbidden due to the isovector nature of the electric dipole radiation. Thus, in the absence of isospin mixing, the yield of high-energy γ-rays in the statistical decay of self-conjugate nuclei populated by entrance channels with the isospin T=0 should be strongly inhibited in comparison with the yield from the $T\neq0$ entrance channels and in nuclei with $N\neq Z$ [1].

In order to extract the isospin mixing in the N=Z compound nucleus of ^{32}S at low excitation, two reactions have been measured using the cyclotron beams at the Heavy Ion Laboratory of Warsaw University: 5.2 MeV/u ^{20}Ne +^{12}C forming isospin T=0 ^{32}S and 4.4 MeV/u ^{19}F +^{12}C forming isospin T= ½ ^{31}P compound nuclei with similar initial excitation energies around 56 MeV. The energy spectra and angular distributions of the γ-rays emitted in the reactions studied have been measured with the multidetector JANOSIK set-up [2]. We have also measured energy spectra and angular distributions of light charged particles by two Si telescopes placed in the vacuum chamber around the target. Statistical character of the reaction mechanism at $E/A \approx 5$ MeV/u has been tested by analyzing measured γ-ray angular distributions and energy spectra of light charged particles. Our statistical model CASCADE calculations reproduce well the γ-ray yields from the $T\neq 0$ ^{31}P compound nuclei, which do not depend strongly on the isospin mixing. Thus we have extracted the amount of isospin mixing in the T=0 ^{32}S compound nuclei by comparing the measured and calculated ratios of γ-ray cross-sections (above E_γ=15 MeV) for reactions in which T=0 and $T\neq 0$ neighboring compound nuclei were formed at similar excitation energies. Statistical model calculations have been performed under the assumption that the isospin mixing spreading width is the same in neighboring nuclei at a given excitation energy. We have extracted the isospin mixing spreading width and the corresponding percentage of the $T_<$ states that mix to the $T_>$ states in reaction forming ^{32}S compound nuclei. Our results are consistent with small isospin mixing, $\alpha^2_< = 0.03+0.02$, at 56 MeV excitation energy, in agreement with [3].

We have also made measurements at higher projectile energy E/A=9.5 MeV/u. At projectile energies above 6 MeV/u, all processes occurring in the heavy-ion collisions: complete and incomplete fusion, preequilibrium nucleon emission and bremsstrahlung γ-ray emission have to be included in the analysis. Statistical γ-ray emission and bremsstrahlung emission may be disentangled by simultaneous analysis of the total cross-section and angular distribution. In order to have a reliable measure of the excitation energy, the mass and charge of the decaying compound nucleus produced in the collision, light emitted particles should be measured and analyzed together with high-energy γ-rays. The analysis of the high-energy data is in progress.

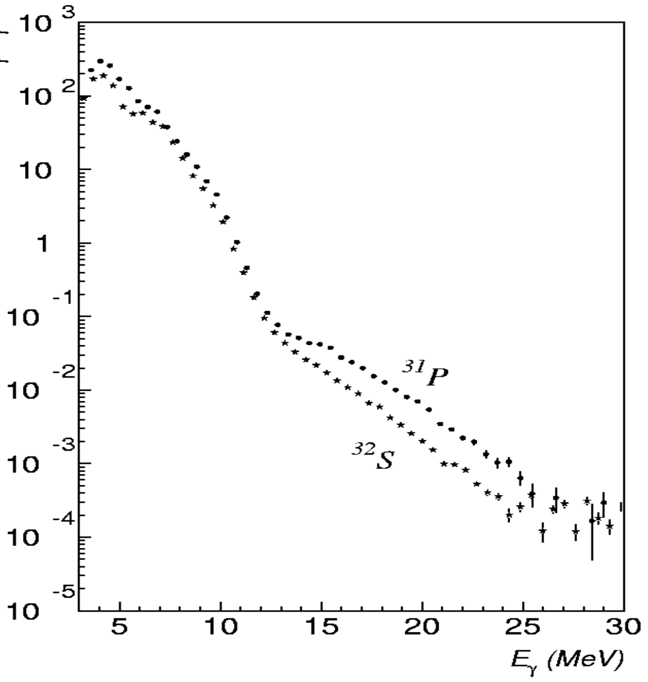

Fig.1. Measured high-energy γ-ray cross-section for ^{19}F + ^{12}C reaction at 4.4 MeV/u and ^{20}Ne + ^{12}C reaction at 5.2 MeV/u.

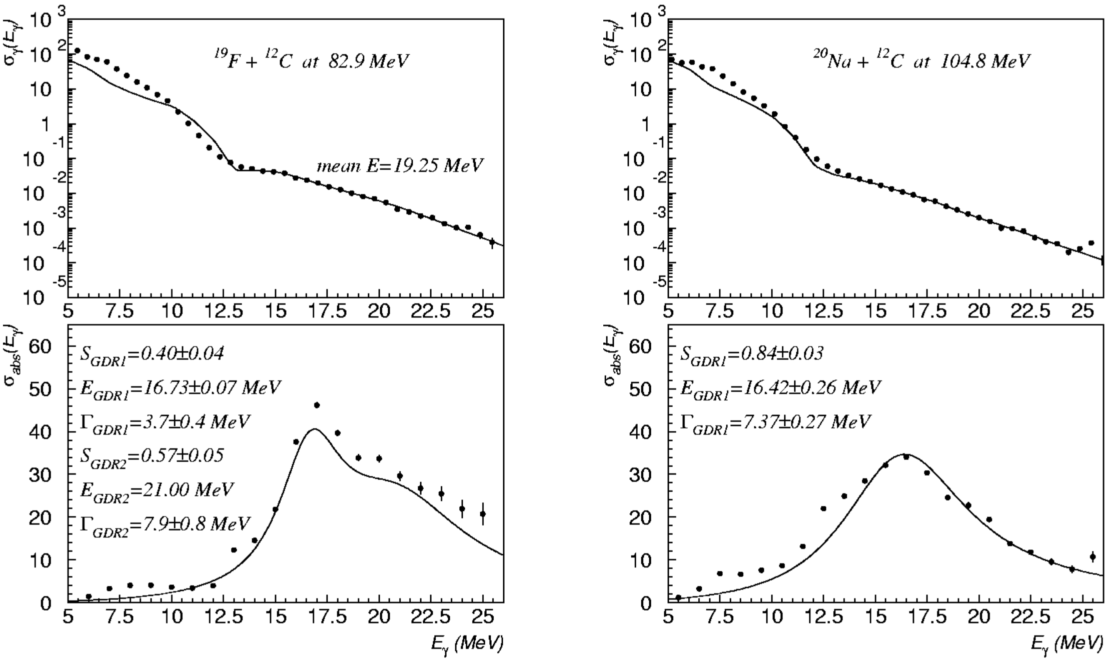

Fig. 2. Measured and fitted high-energy γ-ray spectrum (top) and absorption cross-section (bottom) for ^{19}F + ^{12}C reaction at 4.4 MeV/u (left) and ^{20}Ne + ^{12}C reaction at 5.2 MeV/u (right); points- experimental data, lines - CASCADE fits.

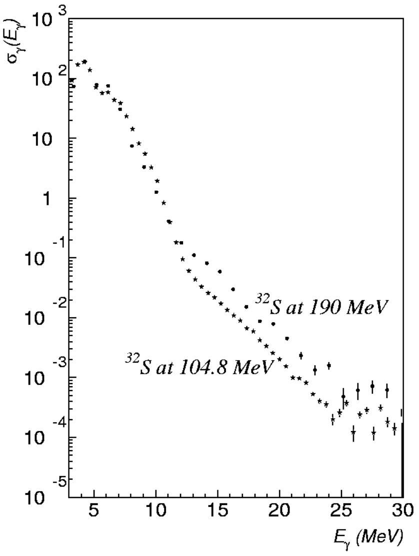

Fig. 3. Measured high-energy γ-ray spectra for ^{20}Ne + ^{12}C reaction at 5.2 MeV/u and 9.5 MeV/u.

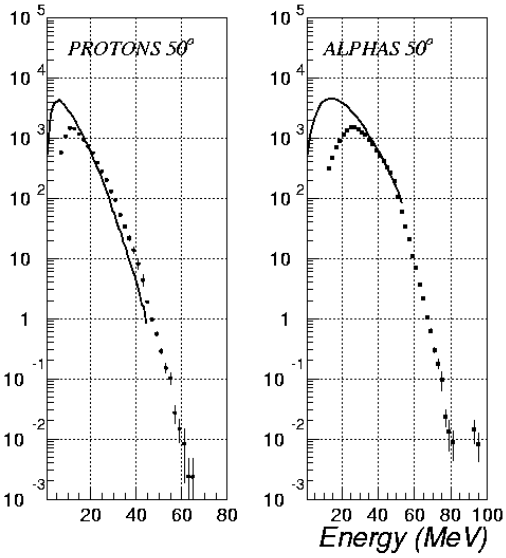

Fig. 4. Energy spectra for protons and alpha particles (laboratory frame) obtained in the ^{20}Ne + ^{12}C reaction at 5.2 MeV/u (points – experimental data , curves – CASCADE calculations).

This work was partly supported by the Polish State Committee for Scientific Research (KBN Grants No. 2 P03B 030 22)

References

[1] M.N. Harakeh *et al.*, Phys. Lett. **B176** (1986) 297.
[2] M. Kicińska-Habior *et al.*, Acta Phys. Pol. **B28** (1997) 219.
[3] J.A. Behr *et al.*, Phys. Rev. Lett. **70** (1993) 3201.

8. Fusion Barrier Distribution in the ^{20}Ne + ^{116,119}Sn system

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The distribution of fusion barrier heights can be studied by quasielastic backward scattering [1]. We have demonstrated [2] that to this end a cyclotron beam can be used instead of the tandem one. This possibility is now being exploited in the Warsaw Cyclotron for studies of the barrier distribution of ^{20}Ne with various targets. The motivation of these studies is the extraordinary deformation of the nucleus (β_2 = 0.72, β_3 = 0.53 [3]), which according to the coupled channel calculations [4,5] should give rise to the strongly structured barrier distribution. We have chosen the ^{116,119}Sn isotopes as the targets because they are sufficiently heavy to make such a structure visible and to make possible comparison of the even-even and odd-even target in the search of any isotopic effect.

Experimental set-up was very similar to that described in our previous paper [2], with only one important change in geometry, namely, the forward detectors were set at 35^{o} in order to be able to register the Rutherford scattering for the studied systems. To make possible small energy steps we utilized the silver foil energy degraders and exploited the angular dependence of the effective cms energy (see ref. [2]).

The results of our measurement are shown in the Fig. 1. Theoretical curves correspond to various energy resolutions: the ideal one and the FWHM of 2.5 MeV, the latter one corresponding to the expected in our measurements.

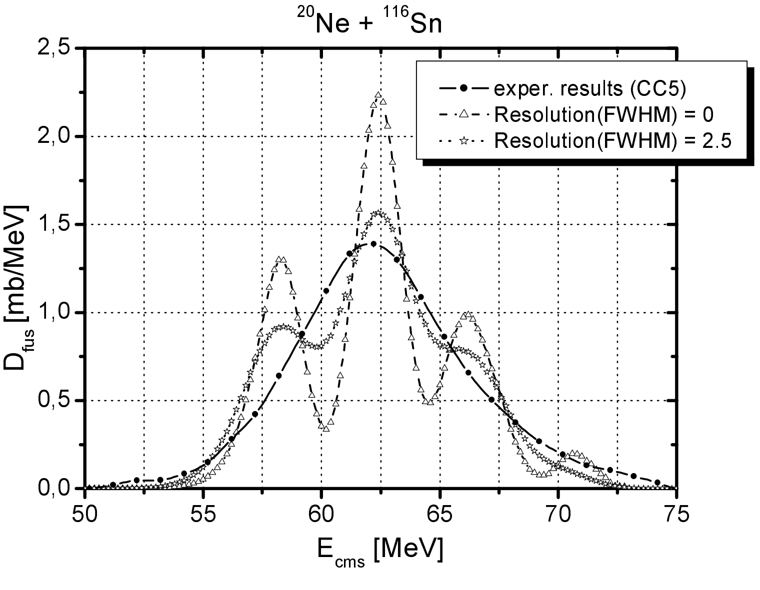

Fig. 1. Comparison of theoretical and experimental barrier distributions.

It is seen that the experimental distribution is extremely smooth, without any trace of the expected structure. We have checked that the barrier distributions for both Sn isotopes are very similar, being only shifted one respect to the other in agreement to the radii difference of the targets.

The smooth shape of the distributions might be caused by experimental problems (underestimated resolution) or by the physical reasons being not taken into account in the theoretical simulations. To decide which of the two reasons was dominating, we are preparing similar experiment to be performed in better experimental conditions: more monochromatic beam and thinner, more homogenous targets.

References

[1] M.Dasgupta *et al.*, Annu. Rev. Nucl. Sci. **42**(1998)401
[2] E.Piasecki *et al.,* Phys. Rev. **C65**, 054611
[3] S.Raman *et al.,* At. Data Nucl. Data Tables **36**(1987)1, Spear, *ibid*. **42**(1989)55
[4] I.J.Thompson, Comput. Phys. Rep. **7** (1988)167
[5] K.Hagino, Comp. Phys. Comm., **123** (1999)143

9. L-subshell ionisation of Au, and Bi by S ions with energy of 0.3 – 3.7 MeV/amu

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The present work is a continuation of our investigations of the L shell ionisation induced by heavy ions with Z ≥ 8 in selected heavy elements (Z ≥ 70). The ionisation of L-subshell of gold and bismuth atoms by an impact of 9.6 – 122 MeV sulphur ions was studied by observing L_α, L_β, and L_γ x-rays.

Sulphur ion beam of incident energies 9.6 – 41.6 MeV and charge states 4^+, 6^+, 7^+ were obtained from EN tandem accelerator at the Erlangen-Nürnberg University and of energies 64, 80, 98, and 120 MeV and charge states 13^+, and 14^+ from the U-200P cyclotron at the Heavy Ion Laboratory of Warsaw University. The targets were irradiated with typical beam currents of 1-10 nA in Erlangen tandem accelerator and about 1-2 nA currents in Warsaw Cyclotron. The beam spot on the targets in both cases was about 2 mm diameter. The experimental set-up used in these two experimental places was the same.

The L-x-rays excited in thin Au and Bi targets (10-40 $\mu g/cm^2$ on thin carbon backings) were measured by a Si(Li) detector placed at 90º to the beam direction with energy resolution of about 200 eV. The production L-x-ray cross section was normalised to the elastically scattered projectiles measured by Si detector kept at an angle of 150º.

The measurements for the highest energies, i.e. for 64, 80, 98, and 120 MeV performed at HIL, aimed to investigate a contribution of the electron capture process to the L-shell vacancy production, which is expected to be dominated by the direct ionisation process for the asymmetric collision studies. However, due to formation of K-shell vacancies in the heavy projectile by its charge-state equilibration in the target, the electron capture could play significant role for high energies even for the projectiles with initially filled K-shell (q ≤ 14). Enhanced L-x-ray yields for highest projectiles energies, with respect direct ionisation would indicate an importance of the electron capture (EC) effect.

In order to study the L-subshell ionisation cross sections, the x-ray production cross sections for $L_{\alpha1,2}(L_3\text{-}M_{4,5})$, $L_{\gamma1}(L_2\text{-}N_4)$, $L_{\gamma2}(L_1\text{-}N_2)$ and $L_{\gamma3}(L_1\text{-}N_3)$ x-ray transitions were obtained. To resolve these peaks the developed method [1] of analysis of x-ray spectra modified by the multiple ionisation effects was used. We were able to resolve unambiguously complex L_γ(L-N,O) transitions (see Fig. 1). The observed x-ray shifting (120-560 eV) and broadening

(90-330 eV) of the lines, which both contain the information on the ionisation probabilities [1], could be quite precisely measured and analysed.

From the production cross sections the L_1-, L_2-, L_3-ionisation cross sections have been calculated using the atomic parameters modified for the multiple ionisation effects [1, 2]. The obtained ionisation L-subshells cross sections are compared with the theoretical predictions of the semiclassical approximation within the united-atom limit (SCA-UA) [3] and the ECPSSR (Energy-loss Coulomb Deflection Perturbation Stationary States Relativistic-effect) [4] theories for direct ionization and for the electron capture (EC) version.

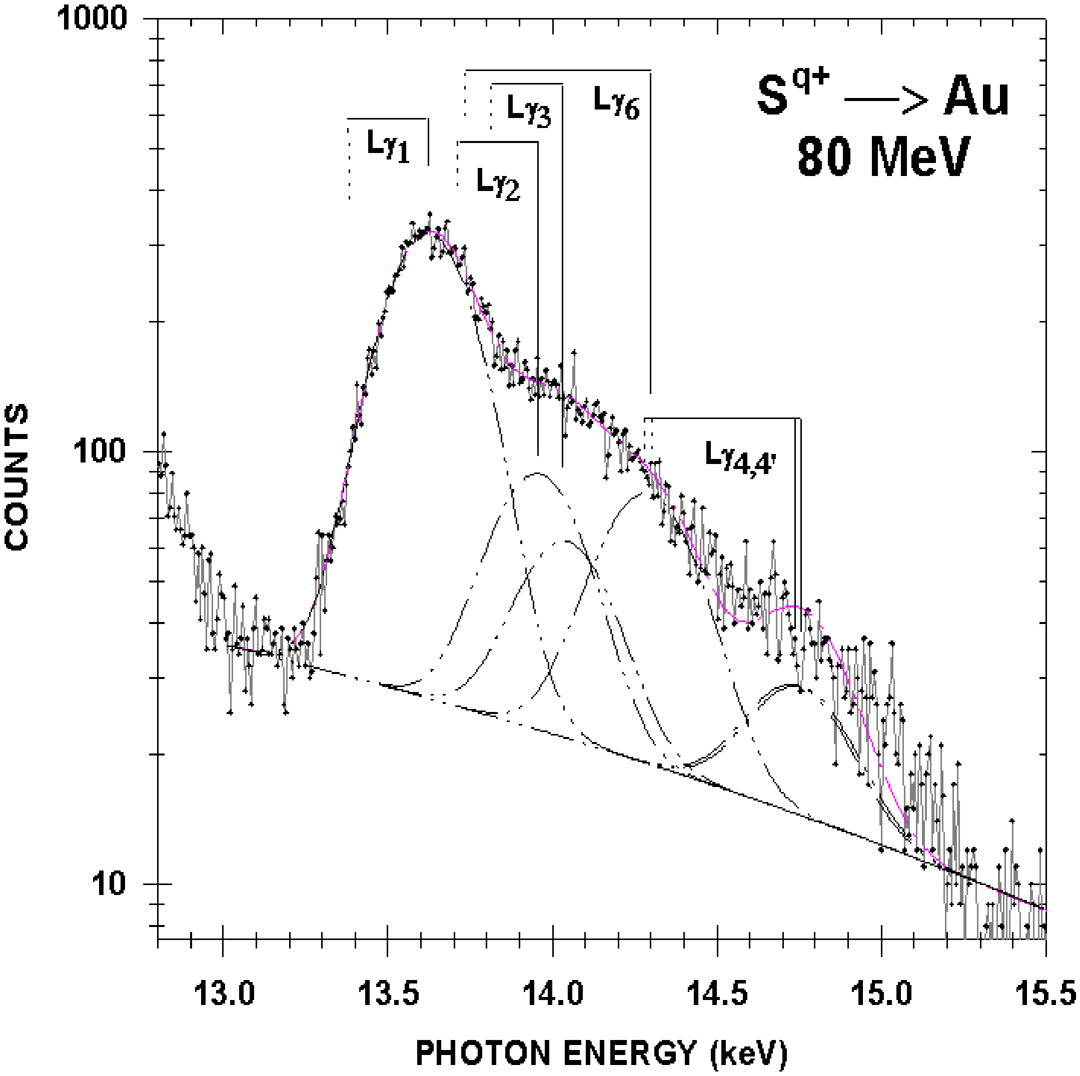

Fig. 1 The L_γ x-ray spectrum for S-ion impact on Au with resolved structure of individual x-ray transitions. X-ray energies of diagram (vertical dashed lines) and shifted (vertical solid lines) lines are shown.

All the three measured L-subshell ionisation cross sections versus the relative projectile-electron velocity v_1/v_2 are compared with the SCA-UA [3], the ECPSSR and ECPSSR + EC calculations on Fig. 2.

As it is seen from Fig. 2 the electron capture process plays a significant role for high energy of sulphur ions and at 120 MeV is about equal to direct ionisation mechanism. This is due to formation of K-shell vacancies in sulphur ions by the charge-state equilibration in the target material (at 120 MeV the average charge state <q>=14.23).

The observed disagreement of experimental and calculated cross sections, particularly for the L_2-subshells clearly suggests a necessity to include the subshell coupling effects in the theoretical treatment of the L-subshell ionisation. It was shown in paper [2] that when subshell coupling effects are introduced in the calculation, the theoretical predictions are in the better agreement with the experimental data.

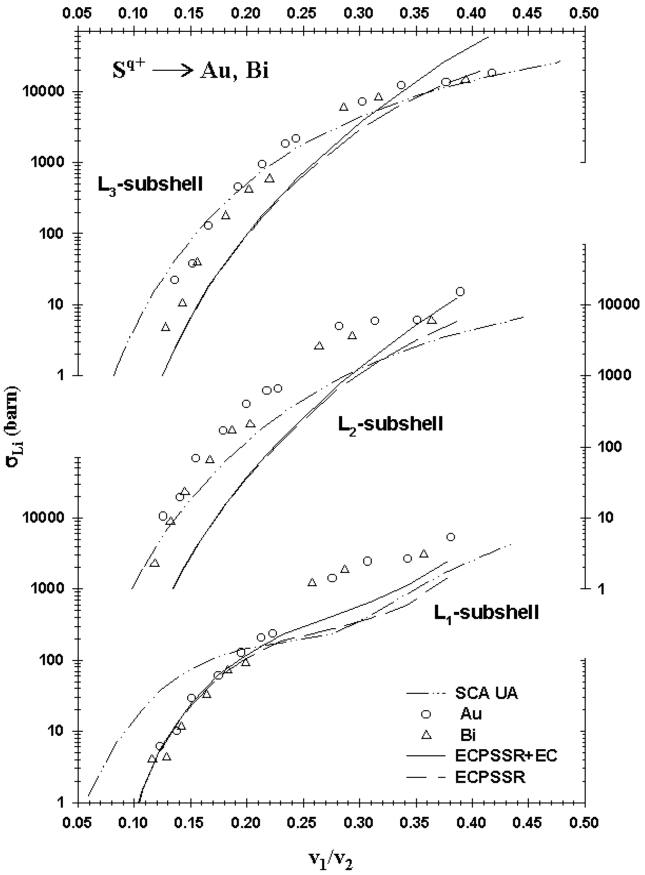

Fig. 2 Measured ionisation cross sections for L_1, L_2 and L_3 subshells of Au, and Bi bombarded by S-ions plotted versus relative projectile to electron velocity v_1/v_1, compared to the SCA-UA [3], ECPSSR [4], and ECPSSR + EC results of calculations.

References

[1] D. Banaś *et al.,* J. Phys. **B33** (2000) L793.
[2] D. Banaś *et al.,* J. Phys. **B35** (2002) 3421.
[3] D. Trautmann and T. Kauer, Nucl. Instr. Meth. **B42** (1989) 449.
[4] W. Brand and G. Łapicki, Phys. Rev. **A23** (1981) 1717.

10. Charged particle veto detector (CUP)

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A highly efficient scintillator particle detector has been constructed. The detector, named CUP, is designed to work as a proton and α-particle veto device in γ-ray spectroscopy fusion-evaporation experiments. It should generate a signal when at least one charged particle is detected and thus should facilitate observation of γ rays from nuclei produced without the emission of charged particles. No attempt is made to distinguish between protons and α particles nor to determine the number of interacting particles. The main intended application of the new device was a large scale experiment with the EUROBALL[1] detector array, in which excited states of the ^{100}In nucleus were studied. In this experiment, which has recently been performed (March 2003), excited states in ^{100}In were populated in the ^{45}Sc(^{58}Ni,3n)^{100}In reaction, and CUP, together with the Neutron Wall[2], was used for selecting very rare events in which only 3 neutrons were emitted. The evaluation of the data collected in this experiment is in progress.

The basic active element of the detector is a cylindrical scintillator “cup” open at one end. It has a diameter of 62 mm, length 85 mm and the scintillator thickness 1 or 0.5 mm (see Fig. 1). The scintillator is placed in the vacuum chamber. The bottom of the scintillator cup is permanently glued to a transparent window. A photomultiplier is connected to the other side of this window. The scintillator thickness was chosen so that sufficient mechanical stability of the cup is assured, an interacting maximum energy proton (30 MeV) generates a large enough signal in the scintillator, and the probability of γ-ray interactions is small.

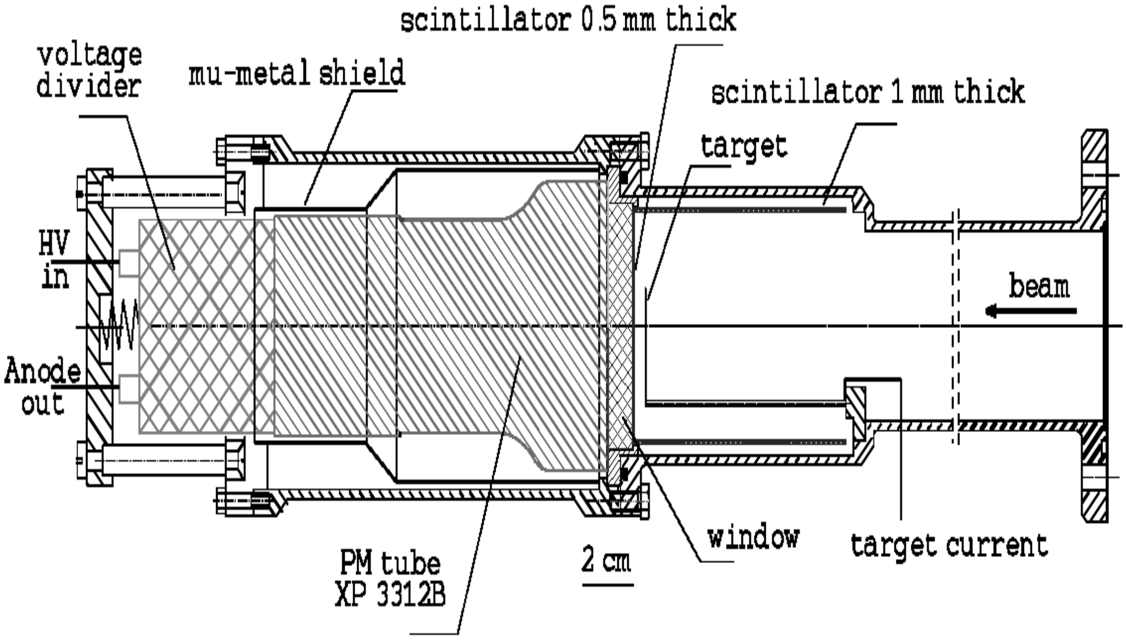

Fig.1 The CUP detector.

The target is situated about 3 mm from the bottom of the cup and is mounted at the end of a rod parallel to the walls of the cup. A specially designed target frame has to be used in order to minimize the number of particles stopped in the frame. The beam has to be stopped in the target. This is the only way to avoid scattering of beam particles into the scintillator, which would be a very significant source of false signals. The device is especially suitable for studying inverse kinematics, or symmetric, reactions. In case of reactions with the beam lighter than the target, backscattered beam particles will interact in the scintillator, again producing false signals. Such backscattered beam particles will have to be stopped by using absorber foils, which can be done at varying efficiency cost, depending on the particular reaction and foils used.

Two in-beam tests of the CUP have been performed at HIL in 2002, and one at IReS, Strasbourg. The performance of the detector determined in the tests done at HIL, for four different fusion-evaporation reactions, is summarized in Table 1.

Tab.1 Proton (e_p) and α-particle (e_α) detection efficiency of the CUP detector. The e_α values in case of reactions 3. and 4. were not determined due to too low statistics collected in these tests.

	Reaction	measured		simulated	
		e_p	e_α	e_p	e_α
1.	^{32}S (160 MeV)+^{124}Sn (23 mg/cm^2)	0.82±0.03	0.62±0.03	0.86	0.37
2.	^{32}S (160 MeV)+^{27}Al (19.4 mg/cm^2)	0.6±0.1	0.63±0.05	0.67	0.38
3.	^{32}S (160 MeV)+^{27}Al (19.4 mg/cm^2)	0.88±0.05		0.83	0.67
4.	^{40}Ar (120 MeV)+^{62}Ni (12.5 mg/cm^2)	0.75±0.05		0.88	0.57

References

[1] J.Simpson, Z.Phys. **A358** (1997) 139
[2] O. Skerppstedt, Nucl.Instr.Meth **A421** (1999) 531

11. Beam tests of the monolithic silicon E-ΔE telescope produced by the Quasi-Selective Epitaxy

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The monolithic, silicon E-ΔE telescope with 20 μm thick ΔE detector followed by 70 μm thick E detector based on the n-p$^+$-n structure was produced using a new developed process named Quasi-Selective Epitaxy [1]. The measurements were performed using the electronic set-up consisting of two preamplifiers followed by active filter amplifiers with time shaping τ= 3 μs. The ADC's analysing E-ΔE signals were gated by 12 μs long logic pulse generated by TFA connected to the E detector preamplifier output. In Fig. 1 the E-ΔE scatter plot is presented after irradiation of the monolithic detector by the α-particles from the thorium calibration source emitting α-particles with energies ^{212}Bi: 6.05 MeV, 6.09 MeV and ^{212}Po: 8.78 MeV (upper left frame). Using such scatter plot the E-ΔE telescope energy resolution (FWHM) was estimated at about 300 keV. The response of the monolithic telescope to the continuous α-particle spectra is measured using the reaction ^{9}Be(^{40}Ar, α) with the beam energy E=184 MeV. For lower energy α-particles registered at the laboratory angle $\vartheta=75^\circ$ (right upper frame) the E-ΔE hyperbola is produced. The α-particles of greater energy were registered at the laboratory angle $\vartheta=75^\circ$ (left down frame). High energy α-particles have crossed the E detector and the hyperbola has been bent at energy about 10 MeV, which corresponds to the thickness E detector depletion layer about 70 μm. Response of the monolithic E-ΔE telescope to heavy ions was investigated using the reaction ^{12}C(^{14}N, X) with the nitrogenous energy of 82.6 MeV at the laboratory angle $\vartheta=20^\circ$. Results are shown in Fig. 2. The following nuclei have been detected with the telescope: He, Li, B, N, O, F, Ne. The ^{7}Be and ^{9}Be stable isotopes are visible in the beryllium banana. The three peaks at the E-ΔE nitrogen hyperbola (at E energies: 44, 50, 56 MeV) correspond to the two lowest excited states and the ground state in the carbon.

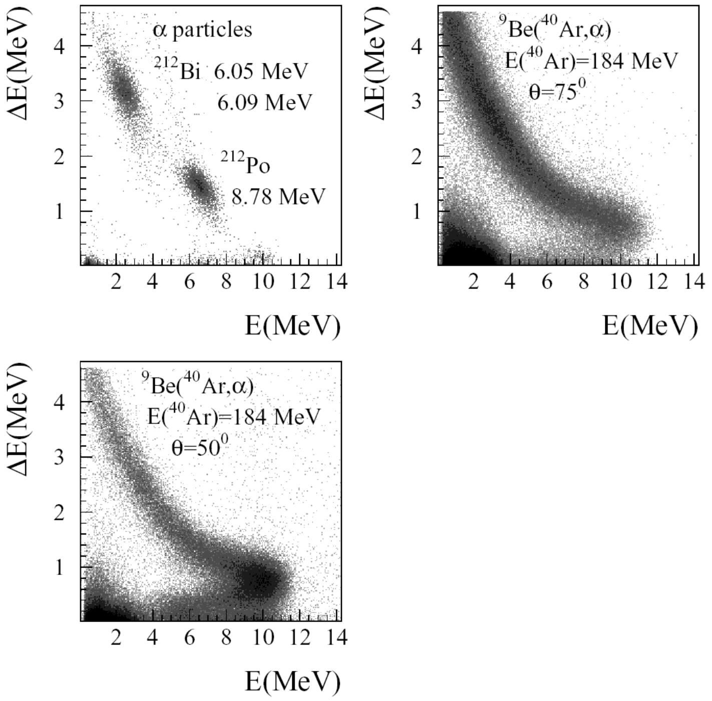

Fig. 1. E-ΔE scatter plots of the monolithic E-ΔE telescope obtained after irradiation by α-particles from the thorium calibration source and resulting from the reaction on beryllium.

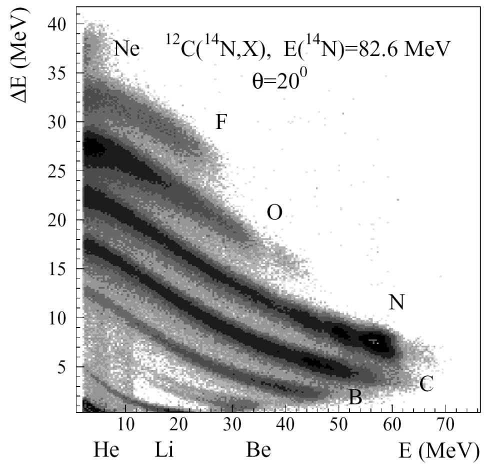

Fig. 2. E-ΔE scatter plot of the monolithic E-ΔE telescope obtained after irradiation by heavy ions.

We have developed a new technology, which gives the possibility to produce monolithic E-ΔE telescopes. The tests of telescopes with different thickness of the ΔE detectors are in progress.

Acknowledgements

This work was supported by the state Committee for Scientific Research, Poland (Grant No. 7 T11B 013 21). M. Kisieliński is acknowledged for fruitful discussions and comments. Excellent co-operation of the Warsaw Cyclotron Crew, especially T. Czosnyka and J. Choiński is very much appreciated.

References

[1] A. J. Kordyasz *et al.,* Nukleonika **48** No. 1 (2003) 31-34

12. Testing of mosaic detector

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In the present days, the importance of the Coulomb excitation technique has been increased with the availability of the radioactive ion beams. The most powerful experimental method is to use the particle-γ coincidence. The excitation pattern is for a given beam and the target combination dependent on the impact parameter. By using the position sensitive particle detector the slices corresponding to different ranges of the scattering angles can be selected, each of them giving independent information. The position sensitive particle detector thus allows to perform several "logical" experiments during a single accelerator run. Additionally, the γ-spectra can be Doppler corrected on the basis of the known relative angle of the recoil particle and the emitted γ-ray to improve the energy resolution.

We have performed an off-beam test of the accuracy of the mosaic Si detector which can be used for the particle detection in Coulomb excitation experiments. The mosaic detector is a semiconductor segmented device, consisting of 35 segments.

During testing, we found that this detector can work even without any bias but a -10V polarising voltage provides the optimum conditions. For the testing of each segment of the detector, a triple (^{241}Am+^{243}Am+^{244}Cm) source was used. This test was done under the vacuum of ~10^{-3}Torr. The preamplifier signal from this detector is shown in Figure 1. One of the resulting spectra from the triple source is shown in Figure 2. These test measurements were performed at the Heavy Ion Laboratory of the Warsaw University

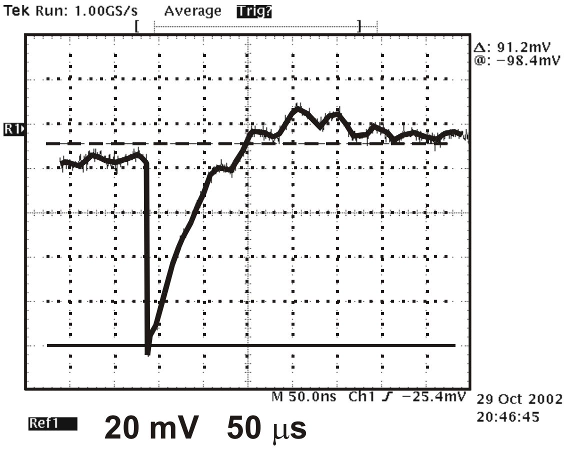

Fig 1. A preamplified signal of ~5 MeV α from a calibration source. The signal to noise ratio can be estimated as ~4 since the detector is very sensitive to noises due to its big capacity.

Since there is no separation of different energies of α-particles from the source (5.5, 5.3 and 5.8 MeV) the estimated energy resolution is about 0.5 MeV (10%). This performance is sufficient for the needs of COULEX experiment. With thin targets the information on the particle scattering angle allows one to determine the whole kinematics of the process. However, the information on the particle energy is useful to reject the events caused by noise or scattering on admixtures in target. It is also crucial when analysing the experiments with thick targets when the incident energy changes due to the beam stopping in the target.

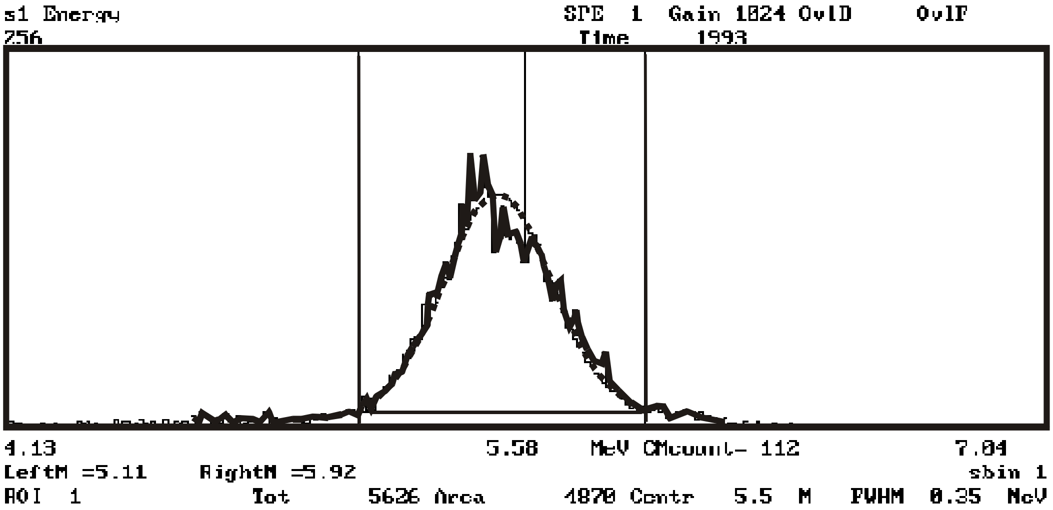

Fig 2. A sample spectrum of ~5 MeV α. The measured resolution of this case is FWHM=0.35 MeV. For other segments the value of FWHM is not worse then 0.5 MeV.

It is also planned to check the detection efficiency of the detectors using the heavy ion beams. We conclude that the inexpensive and easy to use mosaic detector has been proven to be very promising for the future experiment planned in the Nuclear Science Centre, New Delhi.

This project is financed by Polish-Indian joint project 017-00.

13. Structural changes induced by heavy ions in semiconductors

D. Żymierska[1]

Collaboration of:
1) *Polish Acad Sci, Inst Phys, Al Lotnikow 32-46, PL-02668 Warsaw, Poland*
2) *Polish Acad Sci, Inst Phys, PL-02668 Warsaw, Poland*
3) *Heavy Ion Lab UW, PL-02093 Warsaw, Poland*
4) *Inst Electr Mat Technol, PL-02668 Warsaw, Poland*

The aim of the research was to determine by means of X-ray diffraction methods the structural changes induced by heavy ions in semiconducting single crystals. It was shown that the direction of radiation flow is changed in the ion shot-through layer at the depth corresponding to the ion mean range. Taking into account the obtained results we elaborated models of the X-ray energy transmission and of the distribution of deformation in single crystals subjected to deep implantation (20 - 40 μm) by ions with the energy of a few MeV/amu.

In order to perform new experiments of ion implantation, we planed and constructed the special irradiation chamber, which allows one to irradiate different places on the surface of a studied crystal without necessity of opening it. Such construction makes possible to repeat the implantation process many times without renewal pumping, which effects in large saving of time and work. This chamber has been already three times used for implantation of: i) – silicon single crystal with different doses of 2.5 MeV/amu sulphur ions, ii) – defect-free InP and InP:Fe single crystals with different doses (10^{12}, 10^{13}, and 10^{14} cm^{-2}) of 2.5 MeV/amu sulphur ions, as well as iii) – silicon single crystal with 4,6 MeV/amu Ar ions, 2,7 MeV/amu B ions and 3,5 MeV/amu Ar ions for obtaining a buried layered structure. The X-ray structural investigations are in progress.

14. Status of the IGISOL device

A. Wojtasiewicz[1], W. Białowąs[1], G. Canchel[2], A. Emsallem[3], M. Gierlik[1], Z. Janas[1], M. Kisieliński, W. Kurcewicz[1], J. Kurpeta[1], H. Lefort[4], S. Lewandowski[1], A. Płochocki[1], S. Sidor[1], A. Syntfeld[1]

1) Institute of Experimental Physics, Warsaw University, Poland
2) Centre d'Etudes Nucléaire de Bordeaux Gradignan, France
3) Institut de Physique Nucléaire, Lyon, France
4) Institut de Physique Nucléaire, Orsay, France

Following the test experiments with the IGISOL device [1] a series of on-line runs as well as the off-line tests were performed during 2002. Four short on-line tests with ^{14}N (5,5-6,5 MeV/nucleon) incident beam and ^{232}Th and Si targets were performed. This allowed us to estimate roughly the overall efficiency of IGISOL system as 10^{-5} to 10^{-4}.

For a more precise investigation of the IGISOL transmission system an alpha decay recoil source is needed. The ^{223}Ra alpha source was mounted in the special designed ion guide helium cell with remote controlled deplacement of the source inside the chamber. Two Si alpha detectors were used, the first one placed at the front of separator magnet, the second - at the collection point in a new vacuum chamber. The first experiment with the alpha source showed the necessity of improving the vacuum in the extraction region to decrease the neutralisation of ions in this zone. A series of test experiments is planned with the alpha decay recoil source (^{223}Ra) to determine the best parameters of the ion optics, the extraction and the helium supply systems for optimal operation of the facility.

These works are partially performed in the frame of the Warsaw University - IN2P3 (France) and the ION CATCHER collaborations.

References

[1] A. Wojtasiewicz et al. Ann.Rep. HIL Warsaw Univ.(1998) p.15

15. An electron transport system for off- and in-beam measurements

J.Andrzejewski[1], J.Perkowski[1], R.Wojtkiewicz[1], J.Kownacki, M.Kisieliński, A.Stolarz, M.Wolińska-Cichocka[2,3], A.Korman[4], Ch.Droste[3], T.Morek[3], J.Srebrny[3]

1) *Department of Physics, Univ. of Łódź, Poland*
2) *PhD student at HIL*
3) *Nuclear Physics Division, Inst. of Exp. Physics, Warsaw Univ., Poland*
4) *The Andrzej Sołtan Institute for Nuclear Studies, Świerk, Poland*

Internal conversion electron (ICE) spectroscopy plays an important role as a one of the tools of (HI, xnyp) spectroscopy giving the unique possibility for the estimation the nuclear transitions multipolarity. In order to fulfill such requirements the system for transport of electrons from the target area to the place where the detection of delayed ICE after (HI, xnyp)-reaction is less obscured, has been constructed. The electron transport system consists of permanent magnets ring segments made of Nd-Fe-B with internal diameter of 30 mm and total length of 100 mm, and cooled with small Peltier device down to -14 °C Si(Li) detector located at the end of magnetic tube at a distance of ~14 cm from the target (source). The calibration measurements performed with ^{137}Cs and ^{207}Bi sources with and without magnetic field have shown that about 45 times more electrons were observed with magnetic field comparing to those in absence of the field. The in-beam test measurements were performed at the Warsaw Cyclotron using the

^{120}Sn(^{16}O, 4n)^{132}Ce and the ^{98}Mo(^{16}O, xnyp) reactions to study the $e^{-} - \gamma$ coincidences during the beam pulse duration and beyond the beam. In this way, the background in the latter case was significantly reduced. A number of ICE spectra have been recorded with electron transporter operating on-line. In particular the electron spectra gated by 798, 683 and 533 keV γ-rays decaying the $K^{\pi}=8^{-}$ isomer in the nucleus ^{132}Ce [1] were measured. The K/L ratios were preliminary established for 325 ($2^{+} \rightarrow 0^{+}$), 533 ($4^{+} \rightarrow 2^{+}$), 683 ($6^{+} \rightarrow 4^{+}$) and 798 ($8^{-} \rightarrow 6^{+}$) keV transitions. In conclusion, the electron transport system described has been found to provide a useful way of determining the multipolarities of electromagnetic transitions especially in the off-beam mode of cyclotron work.

References:

[1] T.Morek et al. Phys. Rev., C 63, (2001), 0343302.

Part C:

Experiments using the outside facilities

1. Involvement of the HIL physicist in the Coulomb excitation of radioactive beams

T. Czosnyka, J. Iwanicki, P. Napiorkowski, M. Zielińska[1,2]

1) *PhD student at HIL*
2) *Institute of Experimental Physics, Warsaw University, Poland*

The development of radioactive beam facilities offers new possibilities to study the electromagnetic structure of unstable isotopes. The relatively low energy of post-accelerated beams (2-4 MeV/u) makes the Coulomb excitation method an ideal tool for such studies. The Warsaw Coulex group is currently involved in many projects aiming for determination of shape parameters of low-lying excited states in unstable nuclei.

In June 2002 the first Coulomb excitation experiment of a radioactive beam from SPIRAL has been performed to study the shape of ^{76}Kr and ^{74}Kr by collaboration between CEA Saclay, GANIL, NBI Copenhagen, GSI Darmstadt, University of Liverpool, University of Surrey and Heavy Ion Laboratory. During the run Coulomb excitation of a ^{76}Kr SPIRAL beam up to 5 10^5 pps was performed on different targets (^{208}Pb, ^{48}Ti, ^{26}Mg) and at two different beam energies (2.6 and 4.4 MeV/u). The scattered particles were measured by an annular silicon detector in coincidence with the deexcitation γ rays detected in the EXOGAM array.

In the figure below a sample on-line γ-ray spectrum from the experiment with a ^{48}Ti target is shown (no Doppler shift correction has been performed).

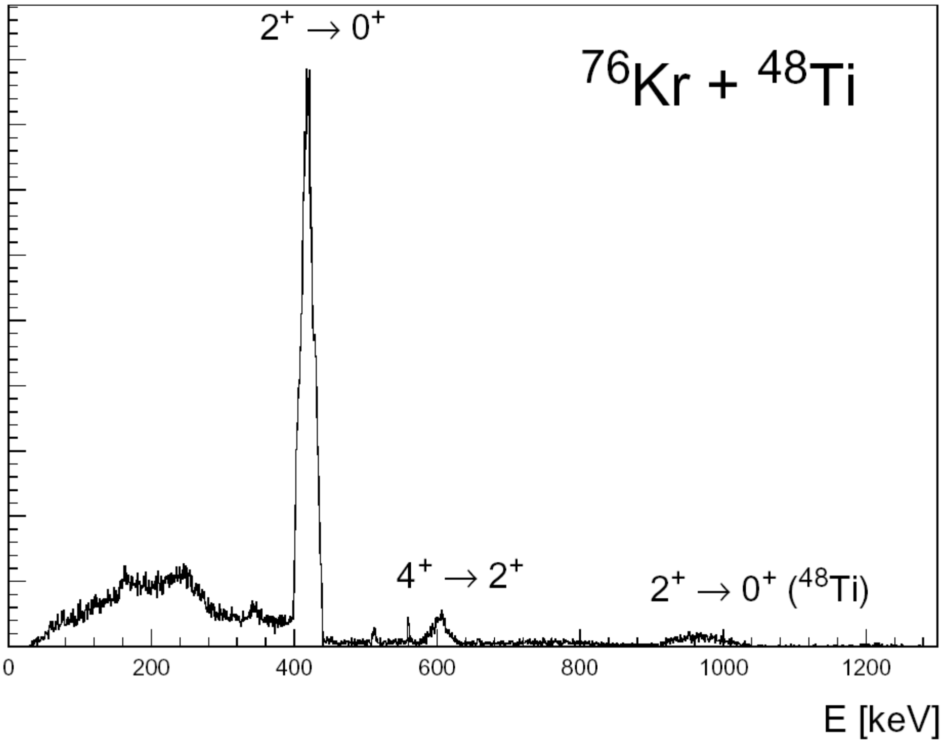

Fig. 1. A typical on-line spectrum from the experiment ^{76}Kr + ^{48}Ti.

Our group is also involved in experiments planned at REX-ISOLDE facility (Coulomb excitation of ^{70}Se, preliminary scheduled for autumn 2003; Coulomb excitation of ^{88}Kr and Coulomb excitation of Sn isotopes). We are participating in calculations, which are necessary to optimize the experimental conditions.

2. Information on the nuclear periphery deduced from the properties of heavy antiprotonic atoms

A. Trzcińska, J. Jastrzębski, P. Lubiński[1], F.J. Hartmann[2], R. Schmidt[2], T. von Egidy[2], B. Kłos[3]

1) CAMK, Warsaw, Poland
1) Physik-Department, Technische Universität München, Garching, Germany
2) Department of Physics, Silesian University, Katowice, Poland

The PS209 experiment gathered a rich set of data on antiprotonic atoms. The progress in the data analysis and its interpretation has been presented already in [1-5]. The data for subsequent isotopes were evaluated: ^{112,116,120,124}Sn, ^{106,116}Cd and ^{122,124,126,128,130}Te.

The differences of root mean square radii of neutrons and protons Δr_{np} determined for these isotopes data slightly changed previously established [3,6] relationship between Δr_{np} and asymmetry parameter δ=(N-Z)/A (see Fig. 1).The new fit gives: $\Delta r_{np}=(-0.03\pm0.02) + (0.90\pm0.15)\delta$.

In the Fig. 2 the normalized neutron to proton density ratios $Z\rho_n/N\rho_p$ for selected isotopes are presented. One can see that there is a good agreement between results derived from antiprotonic atoms data and theoretical predictions from the Hartree-Fock-Bogoliubov calculations. The data are also consistent with the halo factors f_{halo} determined in previous experiments with antiprotons [7-9] using radiochemical methods.

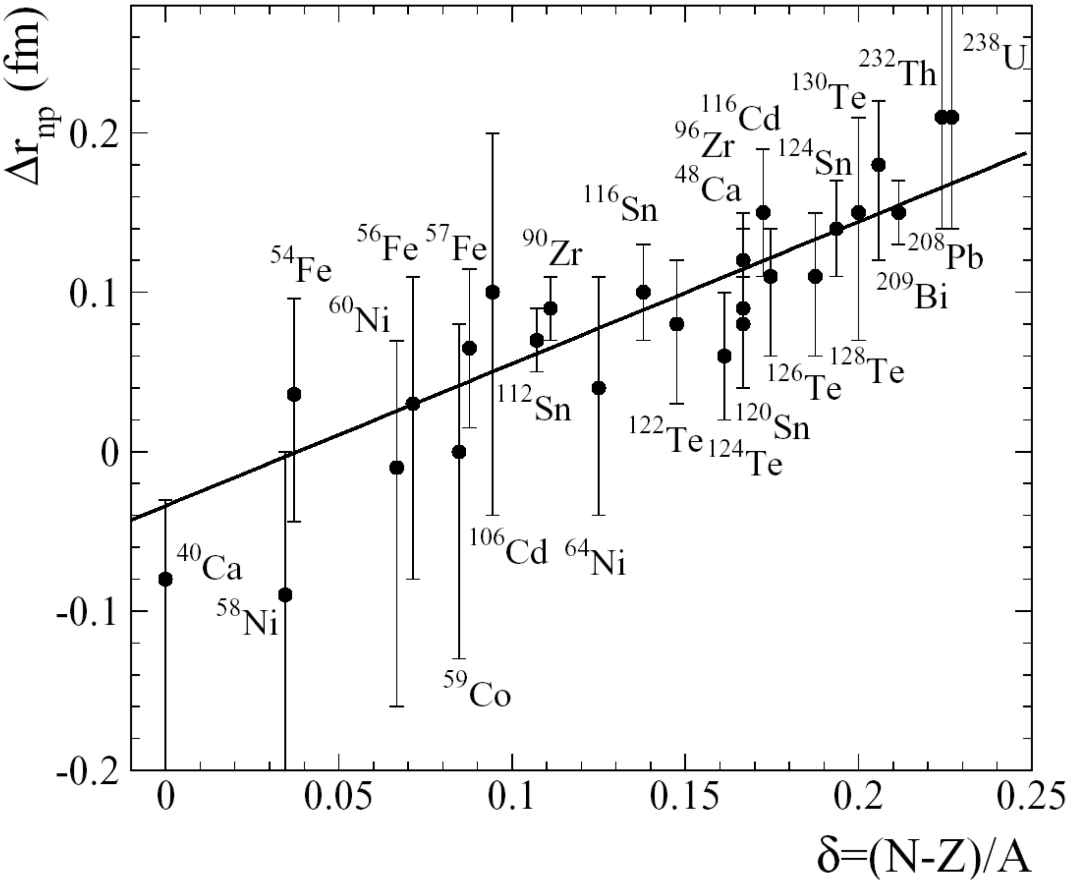

Fig.1 Difference between the rms radii of the neutron and proton distributions as deduced from the antiprotonic atom X-ray data, as a function of δ=(N-Z)/A.The proton distributions were obtained from electron scattering data [10] (Sn nuclei) or from muonic atom data [11-13] (other nuclei). The full line represents the linear relationship between δ and Δr_{np} as obtained from a fit to the experimental data.

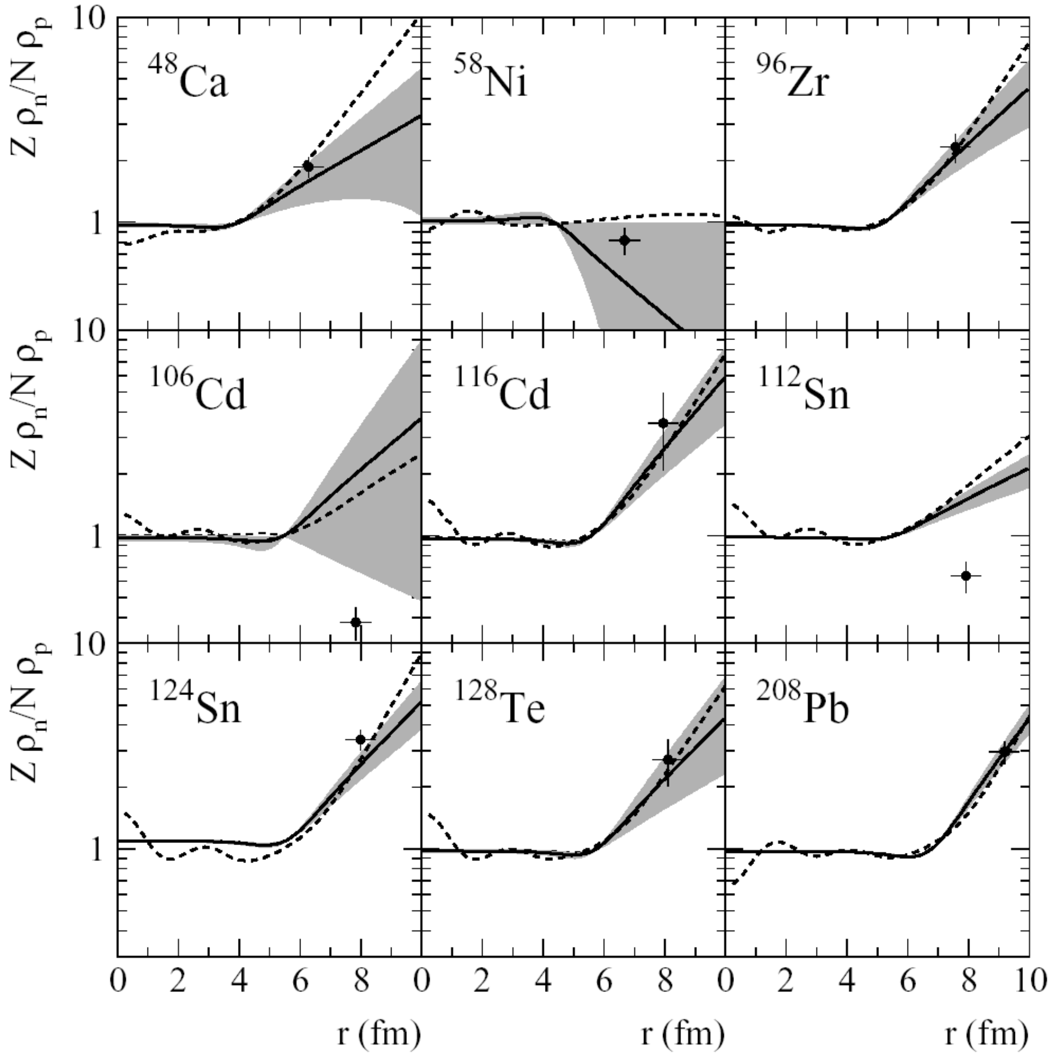

Fig.2 Normalized neutron to proton density ratio $Z\rho_n/N\rho_p$ deduced from the strong-interaction level widths and shifts (solid lines with indicated statistical errors) and charge distributions given in [10] (Sn nuclei) and Ref. [11] (other nuclei). They are compared with f_{halo} measured in the radiochemical experiments (marked with crosses at a radial distance corresponding to the most probable annihilation site) and with the HFB model calculations [14] (dashed lines).

References

[1] HIL Annual Report 1998.
[2] HIL Annual Report 1999-2000.
[3] HIL Annual Report 2001.
[4] A. Trzcińska *et al.*, Nucl. Phys.**A692**. (2201) 176c.
[5] A. Trzcińska *et al.*, Acta Phys. Pol. **32**, (2001) 917.
[6] A. Trzcińska *et al.* Phys. Rev. Lett. **87**, (2001) 082501.
[7] P. Lubiński *et al.*, Phys. Rev. Lett. **73**, 3199 (1994).
[8] P. Lubiński *et al.*, Phys. Rev. C **57**, 2962 (1998).
[9] R. Schmidt *et al.*, Phys. Rev. C **60**, 054309 (1999).
[10] H. de Vries *et al.*, At. Data Nucl. Data Tables, **36**, 495 (1987).
[11] G. Fricke *et al.*, At. Data Nucl. Data Tables **60**, 177 (1995).
[12] J. D. Zumbro *et al.*, Phys. Rev. Lett. **20**, 1888 (1984).
[13] J. D. Zumbro *et al.*, Phys. Lett. **167B**, 383 (1986).
[14] R. Smolańczuk, private communication.

3. Bridging Atomic and Nuclear States in ^{229}Th

B. Arcimowicz[1], B. Błaszczak[3], W. Chmielowski[2,3], S. Chojnacki, J. Dembczynski[1], Yu.P. Gangrsky[2], K. Gromov[2], T.T. Inamura, F.F. Karpeshin[4], B. Markov[1], E. Stachowska[1], M.B. Trzhaskovskaya[5], S. Zemlyanoi[2], and J. Żylicz[6]

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2) Joint Institute for Nuclear Research, Dubna, Russia
3) Department of Physics, Poznań University, Poland
4) Institute of Physics, St. Petersburg State University, Russia
5) Nuclear Physics Institute, Gatchina, St. Petersburg, Russia
6) Institute of Experimental Physics, Warsaw University, Poland

Collaboration of Joint Inst. for Nucl. Res.-Dubna, Dept. of Applied Phys.-Poznań Univ. of Tech., Dept. of Phys.-Poznań Univ., Inst. of Phys.-St. Petersburg Univ., St. Petersburg Nucl. Phys. Inst.-Gatchina, Inst. of Exp. Phys.-Warsaw Univ., and HIL-Warsaw Univ.
Spokesperson: T.T. Inamura

Since it was reported by Kroger and Reich in 1976 [1], an extremely low-lying nuclear isomer in ^{229}Th ($T_{1/2}$ = 7340 y), which is expected at 3.5 ± 1.0 eV today, has attracted considerable attention of chemists as well as physicists; but the evidence for the existence of that isomer has not yet firmly been established. To provide solid evidence, we are planning to do a hollow-cathode lamp spectroscopy of radioactive ^{229}Th atoms that has never been made before. Because of its uniquely low excitation energy in the nucleus, much has been mentioned about the potential applications of ^{229m}Th [2]. However, those are of value only when we have got the solid evidence for that isomer.

We fully exploit electromagnetic properties of atomic and nuclear excitation to populate the isomer in question. The concept of bridging atomic and nuclear states at energies of the order of eV was forged from Coulomb excitation of nuclear states, the hyperfine interaction, and atomic excitation by discharge [3]. As described in Ref. [3], an extended NEET theory has been applied to quantitatively justify that concept to populate the isomer ^{229m}Th: atomic spectra, photo-absorption cross sections and oscillator strengths have been calculated within the framework of the multi-configuration Dirac-Fock method, which provides a basis for comparison with the experiment. It should also be pointed out that the theory suggests population inversion between the ground state and the isomer in question [4].

The radioactive atom ^{229}Th 140 μg in weight will be provided from Dubna: it will be electrolyzed on a small piece of copper foil about 0.1 mm thick; its radioactivity is about 1 MBq. This will be loaded into a hollow cathode lamp with Ar gas at a pressure of 1 mbar and delayed as well as prompt spectra will be measured using a UV spectrograph *Carl Zeiss "Jena"* at Poznań University of Technology.

The 1st preparatory measurement has already been made as is described in the following report.

References:

[1] L.A. Kroger and C.W. Reich, Nucl. Phys. **A259,** 29 (1976).
[2] For example, R.G. Helmer and C.W. Reich, Phys. Rev. **C49**, 1845 (1994).
[3] T.T. Inamura *et al.,*, to be published in J. Czech. J. Phys. **53** (2003).
[4] F.F. Karpeshin *et al*, Phys. Lett. **B372**, 1 (1996).

4. Preparatory measurement of fluorescence spectra of ^{232}Th atom to bridge atomic and nuclear states in ^{229}Th

B. Arcimowicz[1]*, S. Chojnacki, and T.T. Inamura*

1) Department of Applied Physics, Poznań University of Technology, Poland

Collaboration of Dept. of Applied Phys.-Poznań Univ. of Tech. and HIL-Warsaw Univ.
Spokesperson: T.T. Inamura

We made the 1st preparatory measurement with natural Th, i.e. ^{232}Th and alpha source ^{241}Am using a UV spectrograph *Carl Zeiss "Jena"* at Poznań University of Technology. This UV spectrograph covers a region of wavelength 200−700 nm with a good resolution: the region corresponds to an energy range of 2−6 eV that is ideally suited for searching the long-wanted (3.5 ± 1.0)-eV isomer in ^{229}Th. We successfully tested background photons which will be caused by alpha particles emitted from ^{229}Th and fluorescence spectra of ^{232}Th atoms excited by discharge in a hollow cathode lamp.

First, a hollow cathode lamp that we will use to conduct the actual measurement was loaded with natural Th (about 150 mg, 25 mm × 20 mm × 0.025 mm): the amount is approximately that of natural Th to be added as a carrier in extracting radioactive ^{229}Th. The aluminium hollow cathode was water-cooled. Photographic plates WU1 were used to detect photons with wavelengths from 250 nm to 450 nm (about 2.8−5.0 eV). For the present test observation, the discharge condition in the lamp was as follows: Ar gas at about 1 mbar, $V = 160$ V, and $A = 70$ mA. We clearly confirmed fluorescence spectral lines of ThI (neutral) and ThII (singly charged) almost background-free, and concluded that in neutral and singly charged Th all atomic excited states up to the energy well above 7 eV could be populated, some of which should be those building a bridge between atomic and nuclear states in ^{229}Th. To finalize the preparatory measurement, however, it is necessary to test the overall detection efficiency of the spectrograph because in actual measurement we have to deal with an extremely small number of delayed photons, that is to say, afterglow spectroscopy with a UV spectrograph, which has never been made before to our knowledge.

Second, we placed ^{241}Am whose radioactivity was about 550 kBq at the center of a hollow cathode lamp: the activity can be compared to that of 140-μg ^{229}Th (about 1 MBq); and energies of alpha particles can also be compared to each other. To simulate an actual setup, extreme care was exercised using a copper foil and natural Th: the copper foil about 0.1 mm thick will be a backing for Th (^{229}Th and ^{232}Th) to be electrolyzed. We continued exposure with the plate WU1 for 13 hr 20 m at a spectrograph setup of 310−390 nm (about 3.2−4.1 eV) and found there was no trace of photons caused by alpha particles. This is a good indication for our planned measurement. However, it is again important to test the overall detection efficiency. The sensitivity of the photographic plate should be very important. We should also bear in mind that there may be delayed atomic transitions due to the electronic bridge whose energies are considerably lower than 3.5 eV [1]. The intensity of these transitions is predicted to be a few orders of magnitude larger than that of the 3.5-eV nuclear transition [2].

References:

[1] F.F. Karpeshin *et al.*, Phys.Lett. **B372**, 1 (1996).
[2] F.F. Karpeshin *et al.*, Phys. Rev. Lett. **83**, 1072 (1999).

5. Production of ^{24}Na for hyperfine and isotope-shift measurement

S. Chojnacki, Yu.P. Gangrsky[1], T.T. Inamura, D.V. Karaivanov[1], K.P. Marinova[1],
B.N. Markov[1], G.V. Mishinsky[1], S.G. Zemlyanoi[1], and V.I. Zhemenik[1]

1) Flerov Laboratory of Nuclear Reactions, Joint Institute of Nuclear Research, Dubna, Russia

Collaboration of Joint Inst. for Nucl. Res.-Dubna and HIL-Warsaw Univ.
Spokesperson: T.T. Inamura

Heavy-ion irradiation is best to produce high specific activity which is absolutely prerequisite in making off-line fluorescence measurement (hyperfine structure and isotope shifts) of radioactive atoms without chemical and physical separation. Every effort has been made here at the present situation using a ^{14}N beam on a carbon target [1], but it turns out that it is impossible to produce ^{24}Na ($T_{1/2}$ = 15 hr) much enough to carry out such off-line measurement here especially because there is no water cooled internal irradiation system.

In Dubna there is a water cooled irradiation system and a high beam current available to produce ^{24}Na. Unfortunately, however, there is no ^{14}N beam available at present. Instead, we used a ^{12}C beam of 108 MeV on a boron nitride (BN) target 0.5 mm thick. The target was covered with a Ta foil of 20 μm in thickness that was an energy degrader and a protection against vaporizing ^{24}Na produced. The first test irradiation was made at a beam current of about 85 pnA for 2 hr: the total current $Q = 6\times10^{-4}$ particle C. Measuring 1368.7-keV γ rays from ^{24}Na, we estimated the number of ^{24}Na atoms produced to be $(4.4\pm0.5)\times10^{9}$, which was consistent with our previous measurement made here at HIL in Warsaw [1]. To produce more than 5×10^{12} atoms, the minimum number of atoms needed in a confined volume such that 5 mm × 5 mm × 30 μm, during an irradiation period of 2 times $T_{1/2}$, the beam current should be greater than 10 pμA. This request will be achieved in due course.

References:

[1] A. Kopystyńska *et al.,* Ann. Rep. HIL-Warsaw Univ. (1999 – 2000) 30

Part D:

General information on HIL activities

1. Educational activities at HIL

The personnel of HIL, apart from the main duty – providing the heavy ion beams to the users – is also engaged in various educational activities. Four PhD theses were supervised by the Laboratory faculty. Two doctoral programs were completed in 2002 - Agnieszka Trzcińska and Jędrzej Iwanicki were awarded their degrees by the Physics Faculty of the Warsaw University. Four persons from the HIL staff are involved in regular teaching at Student Laboratories of the Physics Faculty on a full time basis. This includes Electronics Laboratory, Basic Physics Laboratory on the first and second level. The practical exercises on target preparation preceded by lecture on preparation techniques have also been organized. The HIL organizes in-house seminars to present the status of the cyclotron, the performed and planned experiments and to popularize the heavy ion physics and its application.

HIL took part in the organization of annual Warsaw Festival of Science. This involvement included the organisation of the distribution of the invitations and guided tours of the facility. Within the program of this Festival Magdalena Zielińska gave a series of lectures on nuclear physics at the layman's level. The laboratory hosted a number of high-school and physics teachers tours, altogether amounting in 2002 to about 35 groups, i.e. 1000 persons.

1.1. PhD Theses

Mgr Agnieszka Trzcińska
Informacje o powierzchni jądrowej uzyskane w drodze analizy promieniowania X atomów antyprotonowych
(Information on the nuclear surface deduced from the X-rays of antiprotonic atoms)
Supervisor: J.Jastrzębski. Thesis defended with honours on January 14th, 2002 r.

Mgr Jędrzej Iwanicki
Badanie struktury elektromagnetycznej jąder atomowych metodą analizy wzbudzenia kulombowskiego
(Electromagnetic structure of atomic nuclei studied via the Coulomb Excitation method)
Supervisor: T.Czosnyka. Thesis defended on February 25th, 2002 r.

2. Seminars

2.1. Seminars at HIL

L.Zemło January 3, 2002
Cyklotron U-200P - rozwiązania konstrukcyjne - cz. II

K.Sudlitz January 10
Sprawozdanie z wizyty w GANILu jak uzyskać wiązki kryptonu i ksenonu

M.Zielińska, M.Palacz, A.Korman January 16
Prezentacja eksperymentów zgłoszonych do wykonania do letnich wakacji 2002

K.Sudlitz January 17
Sprawozdanie z wizyty w GANILu - jak uzyskać wiązki kryptonu i ksenonu - część II

N.Singh May 23
Doublet Rotational Bands in 130 Mass Nuclei

J.Choiński, P.Napiorkowski June 13
Wrażenia z konferencji "Ninth International Workshop on Targetry a nd Target Chemistry"

F.Soga June 20
Diagnosis and Research with Positron Emission Tomography in NIRS

J.Choiński, K. Rusek, E. Piasecki, W. Kurcewicz, Ch. Droste, M. Kicińska-Habior, D. Żymierska, A. Korman, A. Kordyasz, M. Zielińska September 24
Prezentacja eksperymentów zgłoszonych do wykonania na wi ązkach warszawskiego cyklotronu w najbliższym półroczu

O.Tengblad October 12
Beta-decay studies of light exotic nuclei: charge particle Detection

2.2. External seminars given by HIL staff

M.Zielińska March 22
Wzbudzenia kulombowskie jako metoda badania koegzystencji kształtu w jądrach atomowych na przykładzie ^{98}Mo
IFD, Hoża 69

T.Czosnyka April 26
Relatywistyczne wzbudzenia kulombowskie – Projekt RISING
IFD, Hoża 69

A.Trzcińska May 22
Rozkłady gęstości neutronów w jądrach atomowych uzyskane na podstawie badań atomów antyprotonowych
Akademia Świętokrzyska, Kielce

L.Pieńkowski May 22
Emisja ciężkich fragmentów (Z>7) w reakcji pionów z jądrami złota przy pędzie 8 GeV/c
IFD, Hoża 69

T.Czosnyka June 28
Shape coexistence in the medium - mass nuclei
RISING Workshop, Orsay, France

J.Kownacki September 6
Variety of band structures in light Sn, In, and Cd nuclei
The XXXVII Zakopane School of Physics “Trends in Nuclear Physics”
Zakopane, September 3-10, 2002

M.Wolińska-Cichocka September 6

In-beam spectroscopy of nuclei produced in the ^{98}Mo(^{16}O,xnyp) reaction

The XXXVII Zakopane School of Physics "Trends in Nuclear Physics",
Zakopane, September 3-10, 2002

J.Iwanicki September 9

First radioactive beam Coulomb excitation experiment on SPIRAL

The XXXVII Zakopane School of Physics "Trends in Nuclear Physics"
Zakopane, September 3-10, 2002

3. Publications, conference contributions, other publications, internal reports

3.1. Publications in journals listed by ISI

Electromagnetic structure of ^{98}Mo

M. Zielińska, T. Czosnyka, J. Choiński, J. Iwanicki, P. Napiorkowski, J. Srebrny, Y. Toh, M. Oshima, A. Osa, Y. Utsuno, Y. Hatsukawa, J. Katakura, M. Koizumi, M. Matsuda, T. Shizuma, M. Sugawara, T. Morikawa, H. Kusakari, A.D. Efimov,V.M. Mikhajlov
Nucl. Phys. A712, 3 (2002)

Configurations of highly ionized fast sulphur projectiles passing through a carbon foil evaluated from low-resolution K X-ray spectra

U. Majewska, K. Słabkowska, M. Polasik, J. Braziewicz, D. Banaś, T. Czyżewski, I. Fijał, M. Jaskóła, A. Korman, S. Chojnacki
J. Phys. B: At. Mol. Opt. Phys. 35, 1941 (2002)

Barrier distributions in ^{16}O+^{116,119}Sn quasielastic scattering

E. Piasecki, M. Kowalczyk, K. Piasecki, L. Swiderski, J. Srebrny, M. Witecki, F. Carstoiu, W. Czarnacki, K. Rusek, J. Iwanicki, J. Jastrzębski, M. Kisieliński, A. Kordyasz, A. Stolarz, J. Tys, T. Krogulski, N. Rowley
Phys. Rev. C 65, 054611 (2002)

Mechanism of large angle enhancement of the ^{9}Be + ^{11}B scattering

A.T. Rudchik, V.M. Kyryanchuk, A. Budzanowski, V.K. Chernievsky, B. Czech, T. Czosnyka, L. Głowacka, S. Kliczewski, E.I. Koshchy, S.Yu. Mezhevych, A.V.Mokhnach, K. Rusek, S.B. Sakuta, R. Siudak, I. Skwirczyńska, A. Szczurek, L. Zemło
Nucl. Phys. A714, 391(2003)

PIXE and XRF analysis of honey samples

J. Braziewicz, I. Fijał, T. Czyżewski, M. Jaskóła, A. Korman, D. Banaś, A. Kubala-Kukus, U. Majewska, L. Zemło
Nucl. Instrum. Meth. Phys. Res. B187, 231 (2002)

First measurement of the quadrupole moment in the 2_1^+ state of ^{84}Kr
A. Osa, T. Czosnyka, Y. Utsuno, T. Mizusaki, Y. Toh, M. Oshima, M. Koizumi, Y. Hatsukawa, J. Katakura, T. Hayakawa, M. Matsuda, T. Shizuma, M. Sugawara, T. Morikawa, H. Kusakari
Phys. Lett. B546, 48 (2002)

Evidence for excited states in ^{95}Ag
K. Lagergren, B. Cederwall, A. Johnson, J. Blomqvist, D. Sohler, G. de Angelis, P. Bednarczyk, T. Back, T. Claesson, O. Dorvaux, E. Farnea, A. Gadea, M. Górska, L. Milechina, L.-O. Norlin, A. Odahara, M. Palacz, I. Stefanescu, O. Thelen, J.P.Vivien
Eur. Phys. J. A14, 393 (2002)

Neutron excitations across the N=50 shell gap in ^{102}In
D. Sohler, M. Palacz, Zs. Dombrádi, J. Blomqvist, C. Fahlander, L.-O. Norlin, J. Nyberg, T. Bäck, K. Lagergren, D. Rudolph, A. Algora, C. Andreoiu, G. de Angelis, A. Atac, D. Bazzacco, J. Cederkäll, B. Cederwall, B. Fant, E. Farnea, A. Gadea, M. Górska, H. Grawe, N. Hashimito-Saitoh, A. Johnson, A. Kerek, W. Klamra, J. Kownacki, S.M. Lenzi, A. Likar, M. Lipoglavsek, M. Moszyński, D.R. Napoli, C. Rossi-Alvarez, H.A. Roth, T. Saitoh, D. Seweryniak, Ö. Skeppstedt, J. Timár, M. Weiszflog, M. Wolińska
Nucl. Phys. A708, 181 (2002)

Nuclear structure in the vicinity of the N = Z Line in the A = 90 -100 region
A.Johnson (in collaboration with HIL)
Eur. Phys. J. A13, 9 (2002)

Composite-particle emission in the reaction p+Au at 2.5 GeV
A. Letourneau, A. Böhm, J. Galin, B. Lott, A. Péghaire, M. Enke, C.-M. Herbach, D. Hilscher, U. Jahnke, V. Tishchenko, D. Filges, F. Goldenbaum, R.D. Neef, K. Nünighoff, N. Paul, G. Sterzenbach, L. Pieńkowski, J. Tőke, U. Schröder
Nucl. Phys. A712, 133 (2002)

Tracking the phase-transition energy in the disassembly of hot nuclei
C. B. Das, S. Das Gupta, L. Beaulieu, T. Lefort, K. Kwiatkowski,V. E. Viola, S. J. Yennello, L. Pieńkowski, R. G. Korteling, and H. Breuer
Phys. Rev. C 66, 044602 (2002)

Caloric curve of 8 GeV/c π^-, $+^{197}$Au reactions
A. Ruangma, R. Laforest, E. Martin, E. Ramakrishnan, D. J. Rowland, M. Veselsky, E. M. Winchester, S. J. Yennello, L. Beaulieu, W.-c. Hsi, K. Kwiatkowski, T. Lefort, V. E. Viola, A. Botvina, R. G. Korteling, L. Pieńkowski, H. Breuer, S. Gushue, L. P. Remsberg, B. Back
Phys. Rev. C 66, 044603 (2002)

Nucleon density in the nuclear periphery determined with antiprotonic X-rays: Calcium isotopes
F. J. Hartmann, R. Schmidt, B. Ketzer, T. von Egidy,S. Wycech, R. Smolańczuk, T. Czosnyka, J. Jastrzębski, M. Kisieliński, P. Lubiński, P.Napiorkowski, L. Pieńkowski, A. Trzcińska, B. Kłos, K. Gulda, W. Kurcewicz, E. Widmann
Phys. Rev. C 65, 014306 (2002)

Gold fragmentation induced by stopped antiprotons
P. Lubiński, A. Grochulska, T. von Egidy, K. Gulda, F. J. Hartmann, J. Jastrzębski, W. Kurcewicz, L. Pieńkowski, A. Stolarz, A. Trzcińska

Phys. Rev. C 66, 044616 (2002)

Breakup time scale studied in the 8 GeV/c π^- + ^{197}Au reaction
L. Pieńkowski, K. Kwiatkowski, T. Lefort, W.-c. Hsi, L. Beaulieu, V. E. Viola, A. Botvina, R. G. Korteling, R. Laforest, E. Martin, E. Ramakrishnan, D. Rowland, A. Ruangma, E. Winchester, S. J. Yennello, B. Back, H. Breuer, S. Gushue, L. P. Remsberg
Phys. Rev. C 65, 064606 (2002)

Liquid to Vapor Phase Transition in Excited Nuclei
J. B. Elliott, L. G. Moretto, L. Phair, G. J. Wozniak, L. Beaulieu, H. Breuer, R. G. Korteling, K. Kwiatkowski, T. Lefort, L. Pieńkowski, A. Ruangma, V. E. Viola, S. J. Yennello
Phys. Rev. Lett. 88, 042701 (2002)

Coulomb Excitation Paths of High-K Isomer Bands in ^{178}Hf
A. B. Hayes, D. Cline, C. Y. Wu, M. W. Simon, R. Teng, J. Gerl, Ch. Schlegel, H. J. Wollersheim, A. O. Macchiavelli, K. Vetter, P. Napiorkowski, J. Srebrny
Phys. Rev. Lett. 89, 242501 (2002)

3.2. Conference contributions published in ISI listed journals

Large-area thin self-supporting carbon foils with MgO coatings
A. Stolarz, P. Maier-Komor
Nucl. Instrum. Meth. Phys. Res. A480, 194 (2002)
Targets for Particle Beams: Preparation and Use. 20th World Conference of the International Nuclear Target Development Society, Antwerp, Belgium. Chemotrade, 2-6 Oct. 2000

Shape coexistence in ^{98}Mo.
M. Zielińska, T. Czosnyka, J. Choiński, J. Iwanicki, P. Napiorkowski, J. Srebrny, A. Osa, Y. Utsuno, Y. Toh, M. Oshima, Y. Hatsukawa, J. Katakura, M. Koizumi, M. Matsuda, T. Shizuma, M. Sugawara, T. Morikawa, H. Kusakari
Acta Phys. Pol. B33, 515 (2002)
XXVII Mazurian Lakes School of Physics, Krzyże, Poland, 2-9 Sept. 2001

An X-Ray method for identification of the atomic number of the accelerated heavy ion beams
I. Fijał, M. Jaskóła, A. Korman, T. Czyżewski, D. Banaś, J. Braziewicz, U. Majewska, W. Kretschmer, S. Chojnacki
Acta Phys. Pol. B33, 343 (2002)
XXVII Mazurian Lakes School of Physics, Krzyże, Poland, 2-9 Sept. 2001

Fine diffraction effects in Si single crystals implanted with fast Ar ions and annealed
D. Żymierska, K. Godwod, J. Adamczewska, J. Auleytner, J. Choiński, K. Regiński
Acta Phys. Pol. A101, 743 (2002)
Symposium on Synchrotron Crystallography. Krynica-Czarny Potok, Poland. 31 Aug.-4 Sept. 2001.

Response of the PM-355 solid state nuclear track detector to energetic He -, and S-ions
A. Szydłowski, A. Banaszak, T. Czyżewski, I. Fijał, M. Jaskóła, A. Korman, M. Sadowski, J. Choiński, W. Kretschmer
Czech. J. Phys. 52, D921 (2002)
20th Symposium on Plasma Physics and Technology. Prague, Czech Republic. 10-13 June 2002.

Experimental approach towards shell structure at ^{100}Sn and ^{78}Ni
H. Grawe, M. Górska, C. Fahlander, M. Palacz, F. Nowacki, E. Caurier, J.M. Daugas, M. Lewitowicz, M. Sawicka, R. Grzywacz, K. Rykaczewski, O. Sorlin, S. Leenhardt, F. Azaiez
Nucl. Phys. A704 211c-222c (2002)
International RIKEN Symposium Shell Model 2000. Saitama, Japan. 5-8 March 2000.

Light particle production in spallation reactions induced by protons of 0.8 -2.5 GeV incident kinetic energy
C.M. Herbach, A. Bohm, M. Enke, D. Filges, J. Galin, F. Goldenbaum, D. Hilscher, U. Jahnke, A. Letourneau, B. Lott, R.-D. Neef, K. Nunighoff, N. Paul, A. Peghaire, L. Pieńkowski, H. Schaal, W.U. Schroder, G.Sterzenbach, V. Tishchenko, J. Toke
J. Nucl. Sci. Technol. Supplemment 2, 262 (2002)
International Conference on Nuclear Data for Science and Technology (ND2001), Tsukuba, Japan, 7-12 October 2001

3.3. Other conference contributions

Shape coexistence in even-even Ge isotopes

Y. Toh, T. Czosnyka, M. Oshima, T. Hayakawa, M. Sugawara, H. Kusakari, Y. Hatsukawa, M. Matsuda, J. Katakura, N. Shinohara
AIP. American Institute of Physics Conference Proceedings, no.610, 793 (2002)
Nuclear Physics in the 21st Century. International Nuclear Physics Conference INPC 2001. Berkeley, CA, USA. IUPAP. 30 July-3 Aug. 2001

The peripheral neutron distribution in stable nuclei deduced from antiprotonic atoms
A. Trzcińska, J. Jastrzębski, P. Lubiński,F.J. Hartmann,R. Schmidt,T. von Egidy, B. Kłos
AIP. American Institute of Physics Conference Proceedings, no.610, 900 (2002)
Nuclear Physics in the 21st Century. International Nuclear Physics Conference INPC 2001. Berkeley, CA, USA. IUPAP. 30 July-3 Aug. 2001

Breakup time scale studied in the 8 GeV/c π^- + Au reaction.
L. Pieńkowski, K. Kwiatkowski, T. Lefort, W-c. Hsi, L. Beaulieu, V.E. Viola, A. Botvina, B. Back, H. Breuer, S. Gushue, R.G. Korteling, R. Laforest, E. Martin, E. Ramakrishnan, L.P. Remsberg, D. Rowland, A. Ruangma, E. Winchester, S.J. Yennello
AIP. American Institute of Physics Conference Proceedings, no.610, 688 (2002)
Nuclear Physics in the 21st Century. International Nuclear Physics Conference INPC 2001. Berkeley, CA, USA. IUPAP. 30 July-3 Aug. 2001

The coexistence curve of finite charged nuclear matter
J.B. Elliott, L.G. Moretto, L. Phair, G.J. Wozniak, L. Beaulieu, H. Breuer, R.G. Korteling, K. Kwiatkowski, T. Lefort L. Pieńkowski, A. Ruangma, V.E. Viola, S.J. Yennello, S. Albergo, F. Bieser, F.P. Brady, Z. Caccia, D.A. Cebra, A.D. Chacon, J.L. Chance, Y. Choi, S. Costa, M.L. Gilkes, J.A. Hauger, A.S. Hirsch E.L. Hjort, A. Insolia, M. Justice, D. Keane, J.C. Kintner, V. Lindenstruth, M.A. Lisa, H.S. Matis, M. McMahan, C. McParland, W.F.J. Muller, D.L. Olson, M.D. Partlan, N.T. Porile, R. Potenza, G. Rai, J. Rasmussen, H.G. Ritter, J. Romanski, J.L. Romero, G.V. Russo, H. Sann, R.P. Scharenberg, A. Scott, Y. Shao, B.K. Srivastava, T.J.M. Symons, M. Tincknell, C. Tuve, S. Wang, P. Warren, H.H. Wieman, T. Wienold, K. Wolf
AIP. American Institute of Physics Conference Proceedings, no.610, 683 (2002)

Nuclear Physics in the 21st Century. International Nuclear Physics Conference INPC 2001. Berkeley, CA, USA. IUPAP. 30 July-3 Aug. 2001

Trial for extension of the range of ion species at HIMAC
A. Kitagawa, M. Muramatsu, M. Sasaki, S. Yamada, K. Jincho, T. Sakuma, N. Sasaki, H. Takahashi, W. Takasugi, M. Yamamoto, S. Biri, K. Sudlitz, A.G. Drentje
JYFL Research Report 4/2002, 70 (2002)
Proceedings of the 15th International Workshop on ECR Ion Sources ECRIS'02. University of Jyvaskyla,
Jyvaskyla, Finland, 12-14 June, 2002

Status of the Warsaw ECR ion source
K. Sudlitz, E. Kulczycka
JYFL Research Report 4/2002, 46 (2002)
Proceedings of the 15th International Workshop on ECR Ion Sources ECRIS'02. University of Jyvaskyla,
Jyvaskyla, Finland, 12-14 June, 2002

3.4. Other publications

Ogrzewanie półek w liofilizatorze w celu przyśpieszenia suszenia dokumentów
L. Zemło
Notes Konserwatorski, nr 6, 143 (2002)

3.5. Internal reports

The buncher of the HIL cyclotron
J.Sura, E.Kulczycka, T.Bracha, B.Daniel
HIL Internal report 1/02

Dokumentacja zasilacza ZM1
J.Kurzyński, S.Dawidowicz, M.Kopka, P.Krysiak, K.Łabęda, Z.Morozowicz, K.Pietrzak, M.Sobolewski
HIL Internal report 2/02

Zasilacz UZ3
S.Dawidowicz, J.Kurzyński, M.Kopka, P.Krysiak, K.Łabęda, Z.Morozowicz, K.Pietrzak
HIL Internal report 3/03

Zasilacz stabilizowanego prądu ИСТ-3-300-32 (część I)
J.Kurzyński, S.Dawidowicz, V.V.Kharbrov, M.Kopka, P.Krysiak, K.Łabęda, Z.Morozowicz, K.Pietrzak
HIL Internal report 4/02

Zasilacz ИСТ-3-300-32 (część II)
J.Kurzyński, S.Dawidowicz, V.V.Kharbov, M.Kopka, P.Krysiak, K.Łabęda, Z.Morozowicz, K.Pietrzak
HIL Internal report 5/02

4. Laboratory staff

Director: Jerzy Jastrzębski
Deputy directors: Jarosław Choiński and Tomasz Czosnyka
Financial executive Paweł Napiorkowski
Secretary: Maria Wodzińska

Senior Scientists:
Sławomir Chojnacki[a], Tomasz Czosnyka, Takashi T.Inamura[b] (visiting professor), Jerzy Jastrzębski, Jan Kownacki, Ludwik Pieńkowski[c], Józef Sura

Scientific staff and engineers:
Stanisław Dawidowicz, Jerzy Dworski, Bohdan Filipiak, Jędrzej Iwanicki, Andrzej Jakubowski, Viatcheslav Khabrov, Maciej Kisieliński, Andrzej Kordyasz, Michał Kowalczyk[a], Ewa Kulczycka, Janusz Kurzyński[a], Ireneusz Mazur, Jan Miszczak, Marcin Palacz, Mateusz Sobolewski, Anna Stolarz, Krzysztof Sudlitz, Roman Tańczyk[a], Agnieszka Trzcińska, Jan Tys[a], Lucjan Zemło

Doctoral candidates:
Jarosław Choiński, Paweł Napiorkowski, Marzena Wolińska–Cichocka[d], Magdalena Zielińska[d]

Technicians:
Mariusz Antczak, Tomasz Bracha, Bogdan Daniel, Marek Figat, Ryszard Gąsiorowski, Andrzej Górecki, Janusz Jasiński, Piotr Jasiński, Wiesław Kalisiewicz, Zdzisław Kondeja[a], Marian Kopka, Zbigniew Kruszyński, Piotr Krysiak, Krzysztof Łabęda, Zygmunt Morozowicz, Bogusław Paprzycki, Wiesław Perkowski[a], Andrzej Pietrzak, Krzysztof Pietrzak, Ryszard Pozorek, Irena Skrzeczanowska, Sławomira Wąsowska

Administration and support:
Danuta Gałecka, Ewa Sobańska, Krystyna Szczepaniak, Joanna Wasilewska, Wanda Wesoły, Andrzej Wiechowski, Maria Wodzińska.

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a) part time
b) on leave of absence RIKEN and JST, Japan
c) DSc defended at Physics Department of Warsaw University on March 10, 2003
d) PhD student at HIL from Institute of Experimental Physics, Warsaw University

5. Laboratory Scientific Council

1. Prof. dr hab. Andrzej Białynicki-Birula
   Wydział Matematyki, Informatyki i Mechaniki UW
   Warszawa, ul. Banacha 2
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3. Prof. dr hab. Andrzej Budzanowski
   Instytut Fizyki Jądrowej
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4. Prof. dr hab. Katarzyna Chałasińska-Macukow
   Prorektor UW
   00-927 Warszawa, ul. Krakowskie Przedmieście 26/28
5. Dr hab. Tomasz Czosnyka
   Środowiskowe Laboratorium Ciężkich Jonów UW
   02-093 Warszawa, ul. Pasteura 5A
6. Prof. dr hab. Marian Jaskóła
   Instytut Problemów Jądrowych
   Warszawa, ul. Hoża 69
7. Prof. dr hab. Marta Kicińska-Habior
   Wydział Fizyki UW
   Warszawa, ul. Hoża 69
8. Prof. dr hab. Jan Kownacki
   Środowiskowe Laboratorium Ciężkich Jonów UW
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10. Prof. dr hab. Reinhard Kulessa
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12. Doc. dr hab. Krzysztof Rusek
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13. Prof. dr hab. Teresa Rząca-Urban
    Wydział Fizyki UW
    00-681 Warszawa, ul. Hoża 69
14. Dr Brunon Sikora
    Wydział Fizyki UW
    Warszawa, ul. Hoża 69
15. Prof.dr hab. Adam Sobiczewski
    Instytut Problemów Jądrowych
    Warszawa, ul. Hoża 69
16. Prof. dr hab. Jan Styczeń
    Instytut Fizyki Jądrowej
    Kraków, ul. Radzikowskiego 152
17. Prof. dr hab. Ziemowid Sujkowski
    Instytut Problemów Jądrowych
    Świerk k. Otwocka
18. Prof. dr hab. Henryk Szymczak
    Instytut Fizyki PAN
    Warszawa, Al. Lotników 32/46
19. Prof. dr hab. Andrzej Twardowski
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20. Prof. dr hab. Wiktor Zipper
    Uniwersytet Śląski, Instytut Fizyki
    40-007 Katowice, ul. Uniwersytecka 4
21. Prof. dr hab. Jan Żylicz
    Wydział Fizyki UW
    Warszawa, ul. Hoża 69

6. Experimental Committee

Brunon Sikora, IFD UW (Chairman)
Jarosław Choiński, ŚLCJ UW
Tomasz Czosnyka, ŚLCJ UW
Jerzy Jastrzębski, ŚLCJ UW
Reinhard Kulessa, IF UJ
Adam Maj, IFJ
Andrzej Marcinkowski, IPJ
Adam Sobiczewski, IPJ
Teresa Rząca-Urban, IFD UW
Jan Żylicz, IFD UW

The **Users Committee**, serving as a link between the cyclotron users and the Laboratory is chaired by Julian Srebrny (IFD UW).

7. International activities

XXXIII European Cyclotron Progress Meeting

T.Czosnyka

XXXIII European Cyclotron Progress Meeting - 17-21 September 2002 - was organised jointly by Warsaw and Cracow accelerator centres - Heavy Ion Laboratory of the Warsaw University and Niewodniczański Institute of Nuclear Physics, respectively. The event was held at both locations, a new feature in the history of ECPMs. Also, for the first time, the proceedings will be published in International Journal of Nuclear Research Nukleonika.

The conference gathered almost 100 participants from Europe, USA, Canada and Japan. The reports were devoted not only to the cyclotron techniques, but also to the applications - medical, industrial - as well as to the hot subjects in the nuclear science, namely the use of the cyclotrons as radioactive beam sources. Much of the time was spent on the discussions about novel designs of the highly proficient ion sources and associated transport systems. The subject of the ion sources was covered by Santo Gammino (LNS Catania), Claude Bieth (PANTECHIK, Caen), Hannu Koivisto (Jyväskylä) and Vladimir Loginov (Dubna). Jean-Loup Belmont (Grenoble) and Wolfgang Pelzer (HMI) addressed the problems associated with the transport of the low-energy beams from the source to the accelerating structure of the cyclotron. New ideas concerning the acceleration of the hadron beams were presented by Yves Jongen (IBA), Michael Schillo (ACCEL), Anne Paans (Groningen) and Leonid Onischenko (Dubna). Willem Kleeven (IBA), Helge Jungwirth (IKF Jülich) and Jarosław Choiński (HIL Warsaw) discussed the different modes of beam extraction. Finally, Marc Loiselet (Louvain), Marcel Lieuvin (GANIL), Grigorij Gulbekian (Dubna), Gerardo Dutto (TRIUMF) and Sytze Brandenburg (KVI) talked about the developments in radioactive beam facilities. Of course this classification - following the concluding remarks of Heinrich Homeyer (HMI) - is not showing the real scope of the talks of the keynote speakers. All the problems discussed interleave, so the meeting was an excellent opportunity to bring together scientists specializing in sometimes narrow areas.

Besides the participants representing academic and research laboratories commercial companies were also present, stressing the increasing role of the applications of accelerator techniques. ACCEL Instruments GmbH, General Electric Medical Systems and Ion Beam Applications (IBA) presented their offers during permanent exhibitions.

The working visits to the Warsaw heavy-ion cyclotron, the only operating installation of this kind in Central Europe and to the Cracow AIC-144 stimulated agitated exchange of ideas on the basic technical level. Social events were also helpful to give an opportunity for the eye-to-eye discussions not only about the achievements, but also problems. Although welcome reception at the Warsaw cyclotron, followed by the the concert performed by Chamber Choir of the Warsaw Chamber Opera as well as the conference dinner at the Royal Wawel Castle in Cracow did not seem to be an opportunity to argue about space-charge effects, field imperfections and so on, but scientists are always scientists...

The organizers of XXXIII ECPM are thankful for the engagement of the Polish State Committee for Scientific Research, Ministry of Education and Sport and National Atomic Energy Agency, as well as to the industrial companies involved, for the support which, to the great extent, made the event successful and fruitful.

Conference report accepted by NPN News

8. Laboratory Guests

8.1. Short time visitors

E. Perrot	IN2P3, France	January
D. Guerreua	IN2P3, France	January
W. Guy	IN2P3, France	January
Ryugo S.Hayanoi	CERN, Switzerland	January
Johan Nyberg	Uppsala University, Sweden	March, June
Nirmal Singh	Chandigarh University, India	May
A.Sibirtsev	Forschungszentrum Jülich, Germany	May
P.Fedorets	JINR Dubna, Russia	May
V.Grishina	JINR Dubna, Russia	May
F. Soga	NIRS Chiba, Japan	June
P. Singh	Chandigarh University, India	October, November
K.P.Singh	Chandigarh University, India	October

8.2. Visiting professors

T.Inamura	RIKEN and JST, Japan	till November 2002

9. Permanent collaborations

CERN, Geneva, Switzerland
GANIL, Caen, France
Hahn-Meitner Institut Berlin, Germany
Institute für Kernphysik KFA Jülich, Germany
Institute for Nuclear Research, Kiev, Ukraine
Japan Atomic Energy Research Institute, Japan
Joint Institute for Nuclear Research, Dubna, Russia
Ludwig-Maximilians Universität, München, Germany
Manne Siegbahn Institute, Stockholm, Sweden
Niels Bohr Institute, Denmark
Oliver Lodge Laboratory, Liverpool, United Kingdom
Technische Universität München, Germany
University of Jyväskylä, Finland
University of Liverpool, United Kingdom
University of Rochester, USA
Uppsala University, Sweden
Institute of Experimental Physics, Warsaw University, Poland
The Andrzej Soltan Institute for Nuclear Studies, Świerk, Poland
Institute of Nuclear Physics, Bronowice, Kraków, Poland
Department of Physics, University of Łódź, Poland
Institute of Experimental Physics, University of Białystok, Poland
Institute of Physics, Świętokrzyska Academy, Kielce, Poland
Institute of Electronic Materials Technology, Warsaw, Poland

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RAPORT ROCZNY 2002

ŚRODOWISKOWE LABORATORIUM CIĘŻKICH JONÓW
UNIWERSYTET WARSZAWSKI

WARSZAWA, MAY 2003