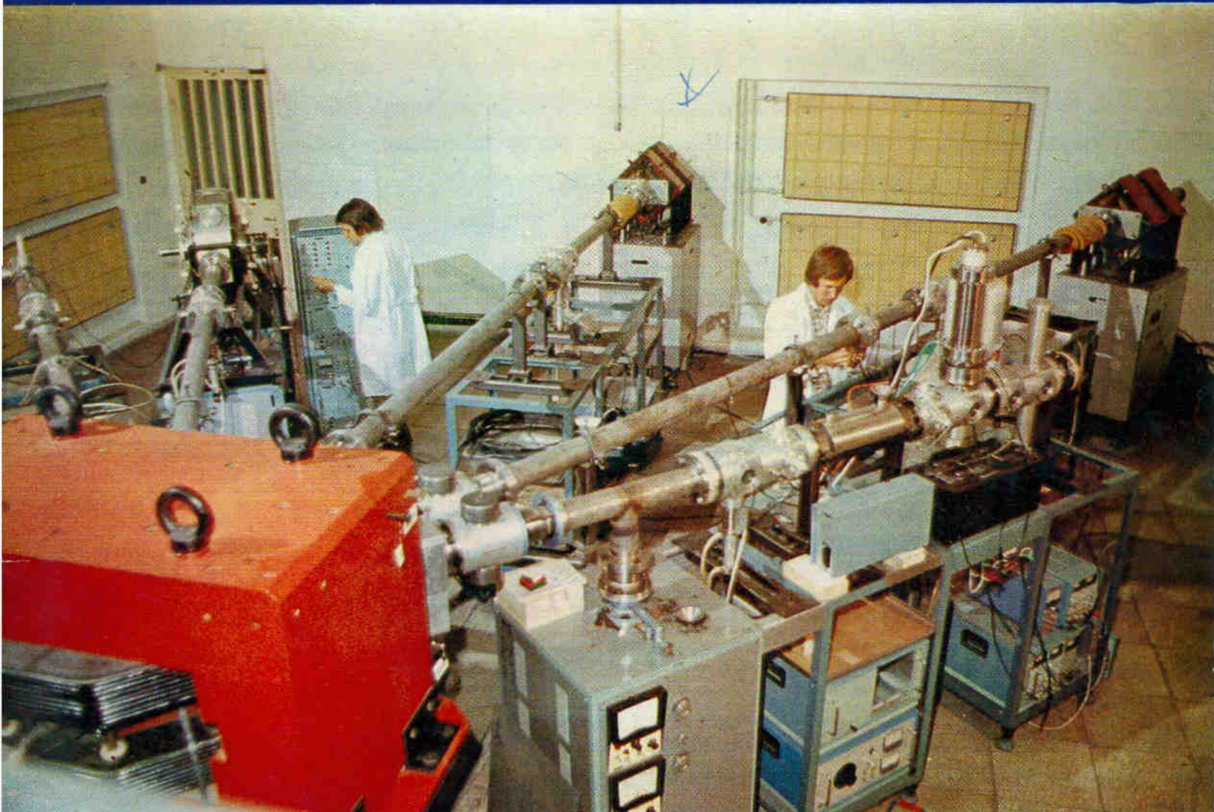
ATOMKI



Institute of Nuclear Research
of the Hungarian Academy of Sciences

Debrecen, Hungary

Front cover: Experimental channels in the main target area of the 5 MV Van de Graaff accelerator

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Debrecen
1981

Contents

The old buildings of ATOMKI from the yard

Introduction

The Institute of Nuclear Research of the Hungarian Academy of Sciences (abbr.: ATOMKI) developed from the Institute for Experimental Physics of Kossuth University, Debrecen. In the Institute for Experimental Physics nuclear research was initiated by A. Szalay, the founder, and director of ATOMKI for more than two decades. After having returned from study-tours abroad, he pursued his work in Debrecen under rather unfavourable conditions with the help of only a few enthusiastic people. After the liberation that work resulted in the development of the "Debrecen scientific school of nuclear physics" and in the foundation of this Institute in 1954.

The Institute works with a relatively small but experienced staff (now nearly 300, including about 100 research workers) and with modest facilities. This very fact determines the choice of research subjects; the Institute tries to tackle problems of nuclear physics that require relatively modest instrumentation but much effort and inventiveness, as well as problems relevant to other fields of science.

The research activities of the Institute are grouped into three main areas: basic nuclear and atomic physics studies, interdisciplinary research and the application of scientific results, and which are harmoniously interrelated. Accordingly, the activities of the staff are almost equally distributed among the three main fields: basic research takes about one third of the total research capacity, and the other two thirds are devoted equally to interdisciplinary research as well as to solving practical tasks, making use of experience gained in both basic and interdisciplinary research.

The achievements attained by ATOMKI are well illustrated by the following data: more than 1700 papers have been published, about one third of them in international journals. From within the Institute more than eighty dissertations for the university's doctorate, about thirty for the "Candidate in Physical Sciences" (CSc), (five of them by foreign physicists), and five for the "Doctor in Physical Sciences" (DSc) have been submitted and defended. The last two degrees are granted by the Academy of Sciences. Three scientists of the Debrecen school of pure and applied nuclear physics (A. Szalay, D. Berényi and J. Csikai) have been elected members of the Hungarian Academy of Sciences.

Members of the Institute have made several important contributions in the fields of both basic and applied science. One of the earliest results, referred to in several textbooks, was the demonstration of *the recoil effect of the neutrino* by photographing the beta decay of ^{6}He in a cloud chamber[1]. *Inner bremsstrahlung* (IB) in positron decay was first observed and examined here on the ^{11}C isotope[2]. The investigation of the IB spectrum of ^{32}P showed that discrepancies in previous findings had been caused by inappropriate experimental conditions. By using magnetic deflection for the beta-rays, it was possible to get rid fo the external bremsstrahlung and obtain agreement with theory in the energy range of the measurement[3].

The investigation of *electron capture* (EC) and related phenomena began twenty years ago with the determination of ratios of EC to positron emission in the radioactive decay of nuclei. E. Vatai has shown that the results of calculations involving exchange and overlap corrections to the EC agree better experiment if the final-state vacancy created by the EC is taken into consideration[4]. In addition, the ratio of nuclear matrix elements can be determined

1 J. Csikai and A. Szalay, International Conference on Mesons and Recently Discovered Particles, Padova–Venezia 1957, Ciclografia Borghero, Padova, 1958, p. IV–8

2 D. Berényi, T. Scharbert and E. Vatai, Nucl. Phys. A124 (1969) 464

3 D. Berényi and D. Varga, Nucl. Phys. A138 (1969) 685

4 E. Vatai, Nucl. Phys. A156 (1970) 541

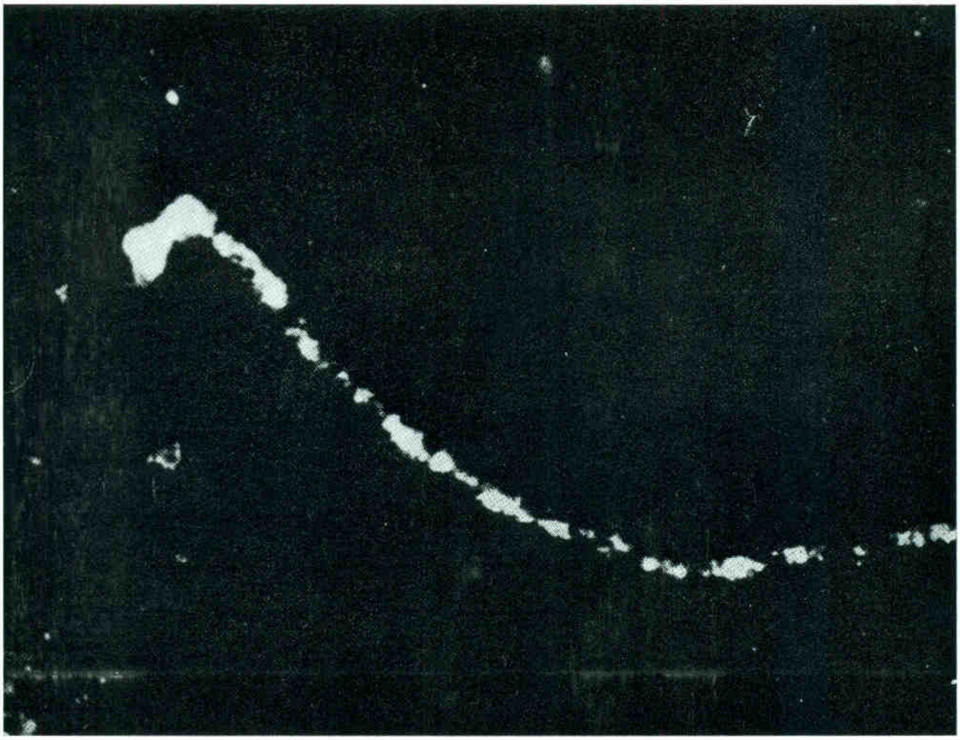
Buildings erected in 1971

from the L/K capture ratio for non-unique forbidden transitions[5]. It was also pointed out that the investigation of ft^+/ft^- ratios in the beta decay of mirror nuclei is not an unambiguous test for the existence of induced tensor interaction[6].

Among the most important results of interdisciplinary research are those which led to the discernment of the governing role of humic acids in the enrichment of several cations in the natural environment.

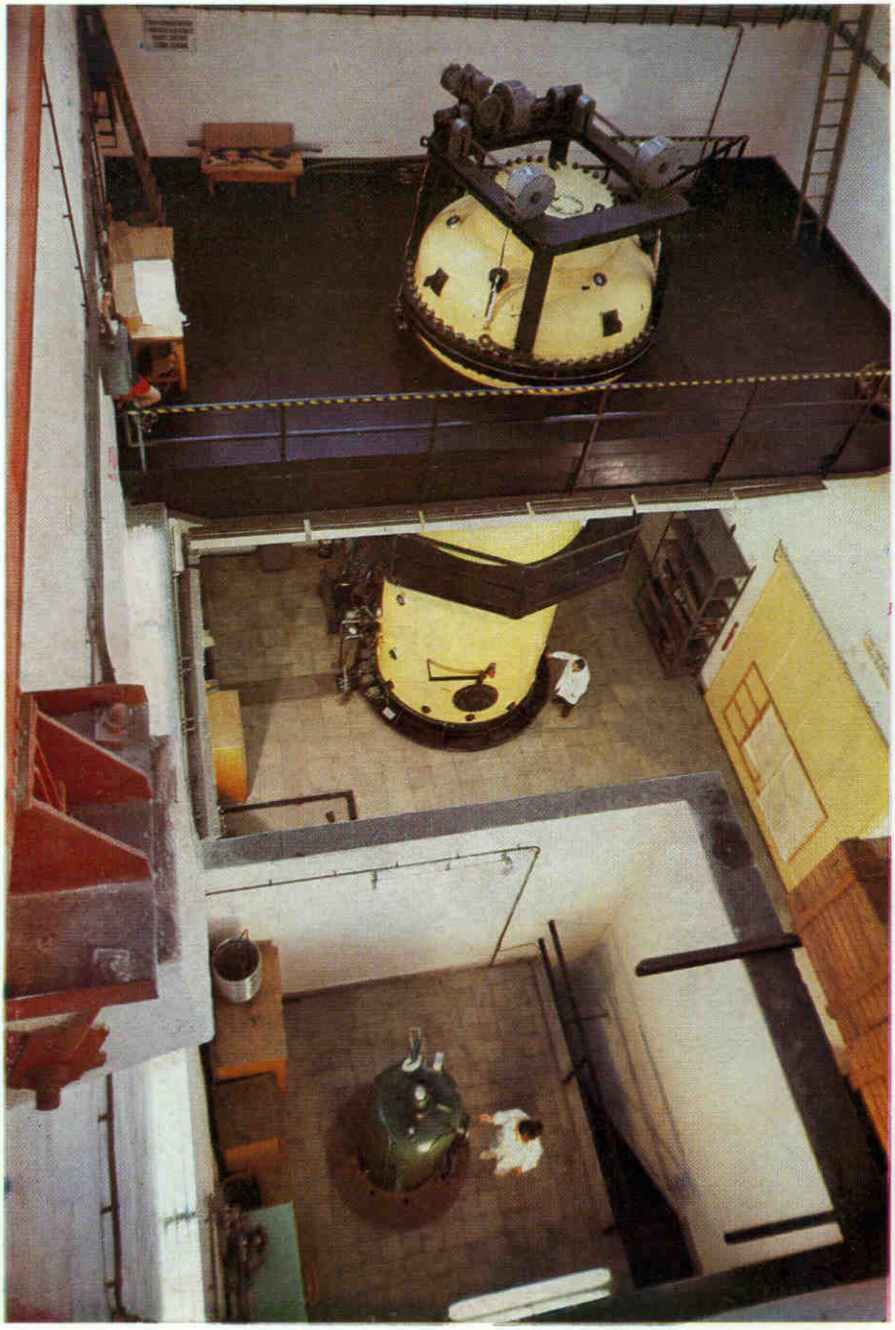
The scientific results and social role of the Institute are appreciated. Many eminent guests – scientists and statesmen (Pál Losonczi, President of the Presidential Council of Hungary among others) – have paid visits to the Institute, and several members of the Institute have been awarded honours and prizes of the State, the Academy of Sciences and of Roland Eötvös Physical Society.

5 E. Vatai, Nucl. Phys. A212 (1973) 413
6 E. Vatai, Phys. Lett. 34B (1971) 395



The recoil effect of the neutrino as seen in a cloud-chamber

Si(Li) electron spectrometer with superconducting magnet transporters for in-beam nuclear spectroscopy



View of the 5 MV and 1 MV Van de Graaff generators

Scientific activities

Nuclear structure and reaction studies

Nuclear structure and reaction mechanism are investigated both experimentally and theoretically in this Institute. Some investigations connected to this field will be discussed together with their applications.

Nuclear spectroscopy

In 1963 close cooperation was established with the Laboratory of Nuclear Problems of the Joint Institute for Nuclear Research, Dubna. Dr. T. Fényes and his group took part in the planning and technical preparation of the program "YASNAPP", and their work in Dubna and Debrecen has contributed to ist realization. The aim of the research in this program was the production of new isotopes and an extensive investigation of *nuclei far from the stability line,* especially in the region of Tl, Hg, Au and the rare earth elements. Over the thirteen years' collaboration about fifty isotopes of sixteen elements were investigated. The most important result was the discovery of ten new isotopes or long-lived isomers of these elements and the determination of many of their properties[7]. The calculated energy levels and electromagnetic properties of even light mercury isotopes explain a number of experimental data and help to understand the structure of these nuclei[8].

In recent years this group carried out in-beam nuclear spectroscopic work, mainly using a superconducting magnetic Si(Li) electron spectrometer. This spectrometer, designed and built in ATOMKI, is unique, having a 76% transmission on the beam of an electrostatic accelerator[9]. With in-beam γ-spectrum, excitation function, γ-angular distribution, scattered proton spectrum, $\gamma\gamma$- and p'γ-coincidence and conversion electron spectrum measurements they identified about 100 new γ-transitions, determined the multipolarity of numerous transitions, and built new level schemes for nuclei in the $A \sim 100$ region.[10]

7 A. G. Demin, T. Fényes, I. Mahunka, V. G. Subbotin and L. Trón, Nucl. Phys. A106 (1967) 337

8 T. Fényes, I. Mahunka, Z. Máté, R. V. Jolos and V. Paar, Nucl. Phys. A247 (1975) 103

9 Z. Árvay, T. Fényes, K. Füle, T. Kibédi, S. László, Z. Máté, Gy. Mórik, D. Novák and F. Tárkányi, Nucl. Instr. Meth. 178 (1980) 85

10 Z. Árvay, T. Fényes, J. Gulyás, T. Kibédi, E. Koltay, A. Krasznahorkay, S. László, V. Paar, S. Brant and Z. Hloušek, Z. Physik A299 (1981) 139

Research directed towards nuclear structure and reaction studies is done mainly on the Van de Graaff accelerators, applying several types of nuclear reactions and techniques.

Proton *elastic scattering* studies were started in 1973 in order to determine the energy, width and spin-parity value of resonances using R-matrix theory. The first result in this field was the proton elastic scattering on ^{40}Ca between 2.3 and 4.85 MeV[11]. The elastic scattering studies have been extended to alpha projectiles too. At present the $^{24}Mg(\alpha,\alpha)$ and $^{19}F(\alpha,\alpha)$ processes are being investigated. The scattering measurements are completed by (p,α); (p,γ) and (α,γ) reactions in which the same compound nuclei produced by scattering are excited in other reaction channels. The solid-state detector technique for alpha particles as developed in this Institute is used for detecting very weak alpha groups in quite high proton background in (p,α) reactions.

In-beam gamma spectrometry with $(p, p'\gamma)$ reaction and high energy-resolution Ge(Li) detectors offer an efficient tool for determining the characteristics of excited levels and constructing level schemes. The first $(p, p'\gamma)$ measurements were carried out on the nucleus ^{45}Sc. Since that time a number of nuclei have been extensively investigated in (p, n) reactions with gamma spectrometry and with the conversion electron method. Among others, the level and decay scheme studies completed on the nuclei ^{82}Br, ^{94}Nb, ^{96}Nb, ^{97}Tc, ^{98}Tc, ^{100}Tc should be mentioned. For spectroscopic purposes the determination of the angular distribution of particle b in an (a, b) process using shape analysis on the gamma peak broadened by the Doppler effect has been performed in the $^{9}Be\,(p, \alpha_2\gamma)\,^{6}Li$[12] and $^{10}B(\alpha, p_1\gamma)^{13}C$ nuclear reactions. The Doppler shift attenuation method (DSAM) was adapted and used in life-time measurements on excited levels in the ^{10}B and ^{14}N nuclei.[13]

Study of nuclear reaction mechanisms

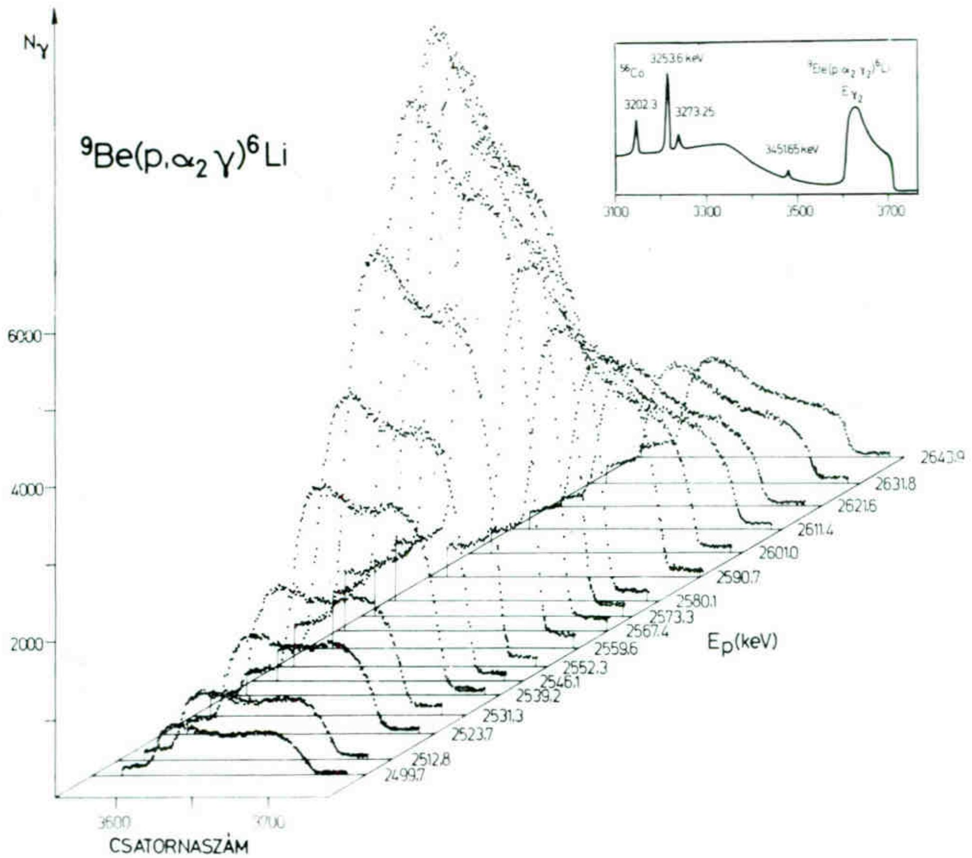
The measurement of (d, p), (d, α) and (d, n) cross-sections on light nuclei with the Cockroft-Walton generator was done in order to study the general features and mechanism of *sub-Coulomb-barrier particle-transfer reactions*[14].

11 E. Koltay, L. Meskó and L. Végh, Nucl. Phys. A249 (1975) 173

12 Á. Kiss, E. Koltay, Gy. Szabó and L. Végh, Nucl. Phys. A282 (1977) 44

13 M. S. Antony, Á. Kiss, E. Koltay, B. Nyakó, and Gy. Szabó, Izv. AN. SSSR, Ser. Fiz. 44 (1980) 1031

14 L. Meskó, B. Schlenk and A. Valek, Acta Phys. Hung. 29 (1970) 365; A. Valek, ibid. 34 (1973) 179

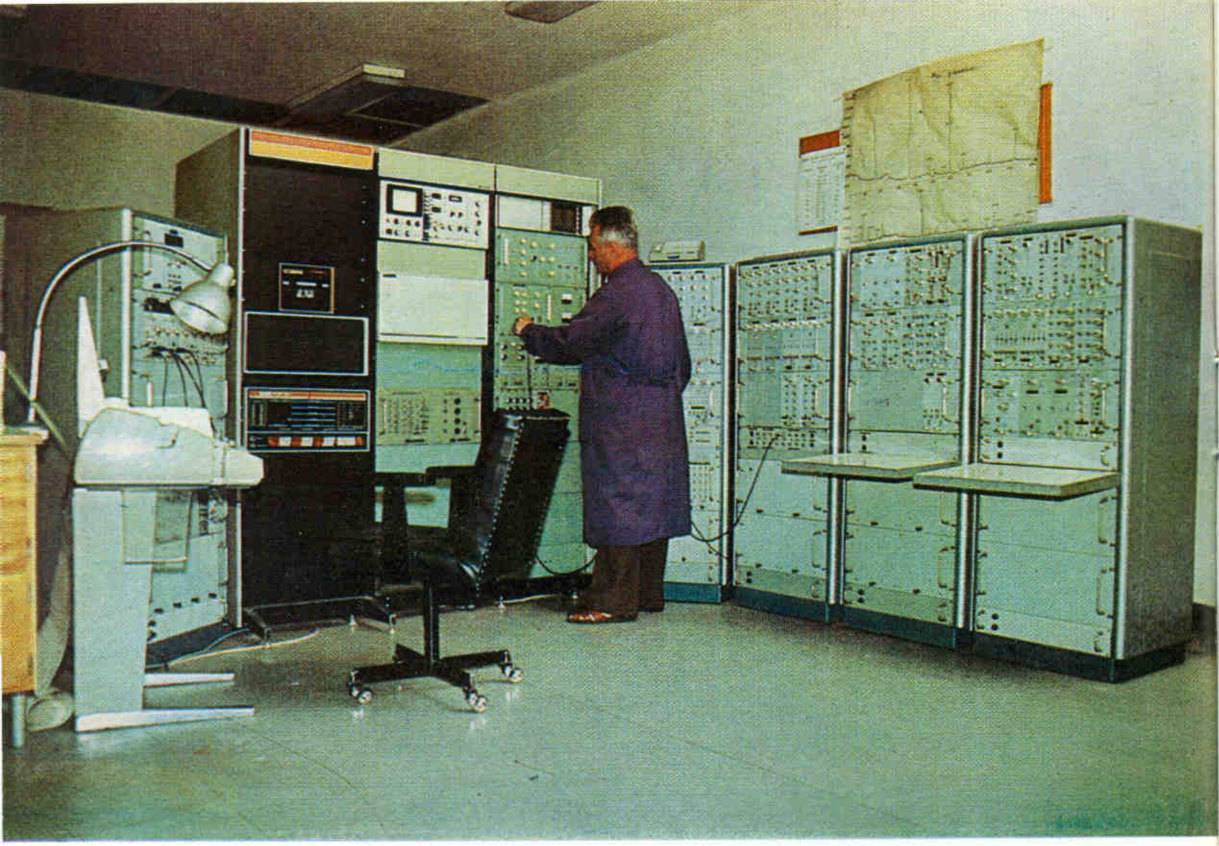


Doppler-broadening of the gamma-line in the $^9Be(p, \alpha_2\gamma_2)\,^6Li$ process.
The measurements were done with the 5 MV Van de Graaff accelerator

The 14 MeV neutrons of a neutron generator have also been used for cross-section measurements on isotopes of heavy elements to clear up the N-Z dependence of (n, 2n)[15] and isotopic effects in (n, p) reaction cross sections. The new ^{198}Ir isotope was produced through the ^{198}Pt (n, p) reaction. The (n, ^{3}He) reaction was first observed here[16].

In cooperation with the Institute of Physics and Power Engineering Obninsk, USSR studies have been carried out to determine the behaviour of the optical parameters of *proton scattering around the Coulomb barrier.*

15 J. Csikai and G. Pető, Phys. Lett. 20 (1966) 52
16 J. Csikai and A. Szalay, Nucl. Phys. 68 (1965) 546



Data acquisition and processing system of the accelerator laboratory

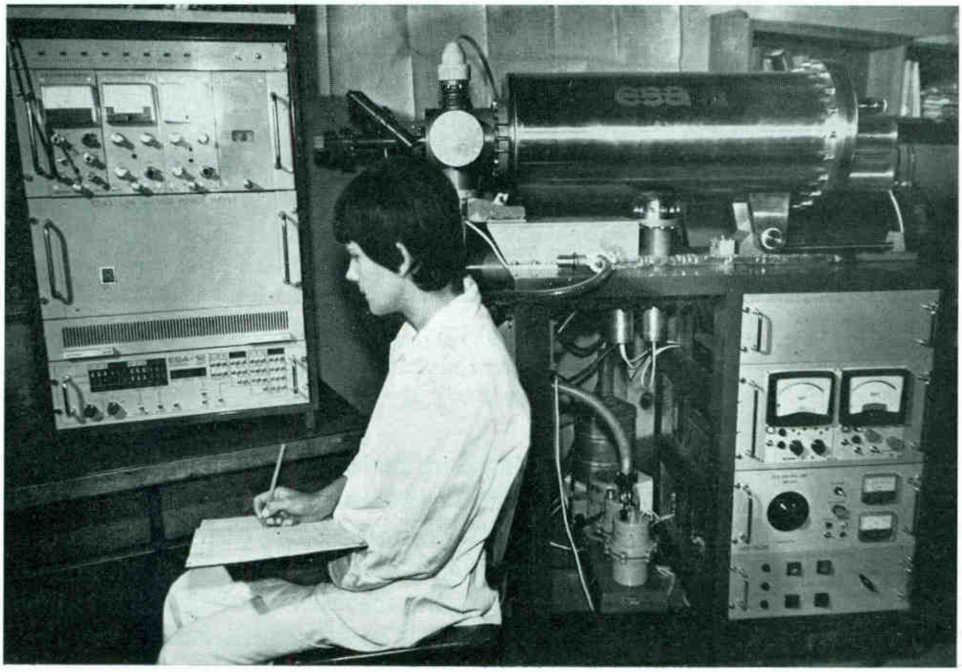
One of the main fields of activity in *nuclear theory* was the description of resonant states and, in particular, isobaric analogue resonances. It has been shown that the resonance wave functions with purely outgoing spherical waves in infinity, called the Gamow functions, have very practical applications[17]. One of the first microscopic calculations of the asymmetry term of the Lane potential was that of J. Zimányi and B. Gyarmati[18]. In recent work the self-consistency of the Lane potential has been investigated phenomenologically. Papers have contributed to the understanding of the role of inelastic multi-step processes in transfer reactions and to the estimation of the effect induced by the presence of single-particle states near the thresholds of reaction channels[19]. Further aspects of channel and particle correlation and coupling in direct and semi-direct processes were studied too. Recently, work towards the microscopic description of the structure and processes of light nuclei has been started.

17 E. g.: B. Gyarmati and T. Vertse, Nucl. Phys. A160 (1971) 523
18 J. Zimányi and B. Gyarmati, Phys. Rev. 174 (1968) 1112
19 E. g.: B. Gyarmati, A. M. Lane and J. Zimányi, Phys. Lett. 50B (1974) 316

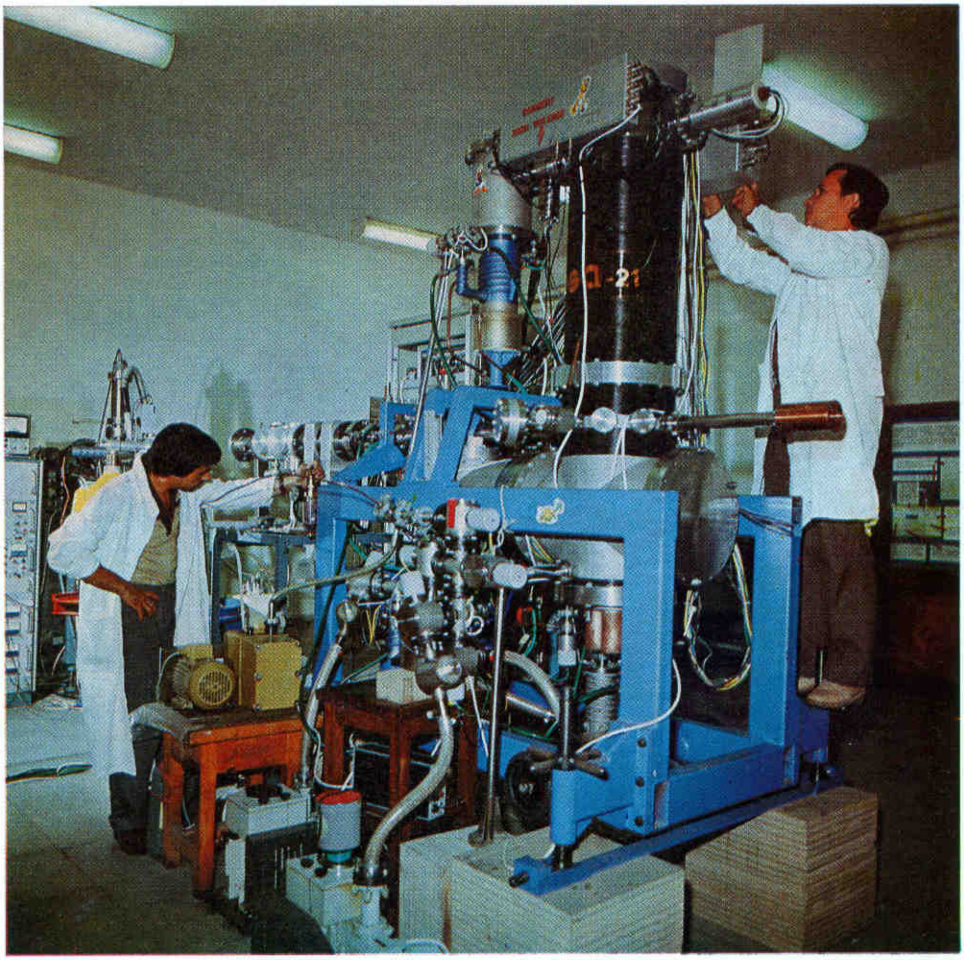
Studies in atomic physics

Although the main research area of the Institute is experimental nuclear physics, considerable interest has been taken, ever since the early years, in other branches of science as well. Recently atomic physics has become an interesting and highly productive field, and is studied by making extensive use of experience gained in basic nuclear physics, as well as of the equipment and techniques of nuclear research.

Electrons, protons, deuterons in the 60...600 keV energy region are used to produce characteristic X-rays and electrons from the electron shell of atoms, the X-rays being detected with Si(Li) detectors and the electrons by home-made electrostatic electron spectrometers respectively. K, L, M X-ray production and subshell ionization cross-sections under electron impact or light and heavy ion bombardment have been measured on a number of heavy and medium



Electron spectrometer built for the Central Institute for Nuclear Research of the Czech Academy of Sciences



Electrostatic electron spectrometer to the study of ionization processes induced by high-energy particles (ESA–21)

weight atoms. A series of $K\alpha/K\beta$ intensity ratio measurements covered the gap between $Z=30$ and $Z=57$. In the case of gold under proton and He^{+} bombardment the angular distribution of the $L_e/L\gamma$ intensity ratio has also been measured. In all cases the experimental data have been compared with one or more of the existing theories concerning the mechanism of the atomic inner shell ionization. Some disagreement between measurement and theory drew attention to the importance of multiple ionization in X-ray production during heavy ion bombardment.[20]

The investigations into the spectra of ejected electrons are at a preliminary stage, nevertheless, interesting results have been obtained on light but structured systems, namely on those present in H_2^+, He^+–H_2, He collisions.[21]

Interdisciplinary research

Although the main research area of the Institute is experimental nuclear and atomic physics, considerable interest has been taken from the early years on in other branches of science as well. Experience gained in fundamental nuclear and atomic physics research and instrument construction found its way to application in quite a number of fields of basic and applied research: in the various areas of chemistry, agriculture, the earth sciences, as well as of medical, biological and environmental research.

Applied electron spectrometry

The kinetic spectra of photoelectrons produced by monochromatic X-ray excitation contain information on the chemical structure of the material under bombardment. The low-energy electrostatic electron spectrometers developed in the Institute have been adapted to make such kinds of investigations possible. In recent years several problems of surface chemistry have been investigated. Research included the study of the properties of oxide layers produced on platinum surfaces, and studies concerning the mechanism of surface oxidation of stainless steel.

Geochemistry and microelement research

Research in *geochemistry* started with the discovery of uranium enrichment in some coals of Hungary in 1949. Prof. A. Szalay and his group recognized that in the geochemical circulation of natural waters it is the humic acids that retain, through ion exchange, a considerable portion of uranium and other high atomic weight cations.[22]

20 L. Sarkadi and T. Mukoyama, J. Phys. B: Atom. Molec. Phys. 13 (1980) 2255
21 A. Kövér, S. Ritz, Gy. Szabó, D. Berényi, E. Koltay and J. Végh, Phys. Lett. 79A (1980) 305
22 A. Szalay, Acta Phys. Hung. 8 (1957) 25

Laboratory and workshop buildings built in 1980–81

The further study of this topic led to results of great relevance to the *agricultural* cultivation of hundreds of millions of hectares in the world. The cation exchange retention by humic acids often results in the micronutrient starvation of plants grown on peat soil despite the fact that these elements are present in the soil in sufficient quantities. The experiments have shown that dilute solutions sprayed on to leaves brought about a remarkable increase in yield and also an improvement in quality.

Current research in this field involves the study of micronutrient-deficient areas of Hungary as well as the study of microelements in the human diet. The study of microelements in the whole food cycle including humans extends this work into the field of *biomedical research.*

The radioactive gases of the natural environment (Rn, Tn) can be measured in extremely low concentrations by using solid state track detectors. The natural factors controlling the distribution and migration of radon in the environment are being investigated by applying these techniques.

Portable GM counter used in uranium prospecting (1949)

Measuring the radon content of air in a cave by solid state track detectors

Geochronology

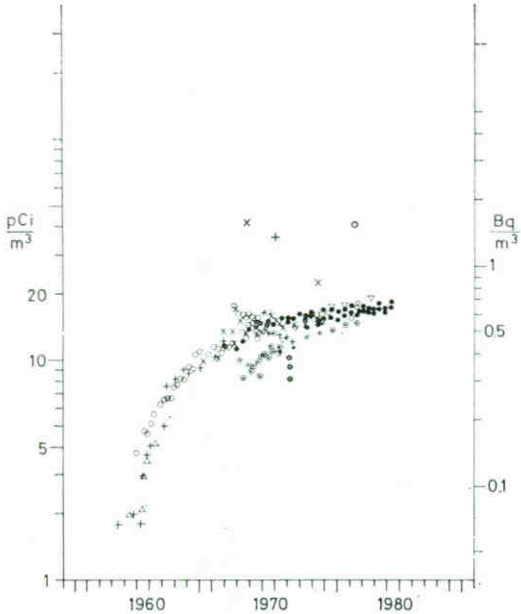
Radiometric dating is done by the Rb-Sr and K-Ar methods. Rb-Sr dating projects are carried out on igneous and metamorphic rocks, whereas the K-Ar method is mainly applied in dating the volcanic rocks of Hungary. The argon extraction and purification system and the mass spectrometer used for K-Ar dating were developed in this Institute, while the Rb-Sr dating work is done with Soviet-made mass spectrometers of MI 1305 and MI 1309 type.

Environmental research

The work in this field started in 1952 with studies on *atmospheric radioactivity*. Since then regular measurements have been made on the total beta radioactivity of the precipitation due to fission products released in atmospheric nuclear weapon tests.

Since 1966 the investigations have been extended to the systematic measurement of ^{85}Kr pollution in the atmosphere. This pollution, arising from the reprocessing of burnt uranium fuel rods of nuclear industry, is gradually increasing although at present it is well below the danger level.

A low-background counting system has been recently constructed to measure ^{14}C activities at the natural concentration level. It is used in the dating of fossile organic material with its aspects relevant both to archaeology and Quaternary stratigraphy. Environmental studies involve the determination of ^{14}C activities in recent organic material.



Measured atmospheric ^{85}Kr concentrations (●: measurements made in ATOMKI)

Chemical analysis using nuclear techniques

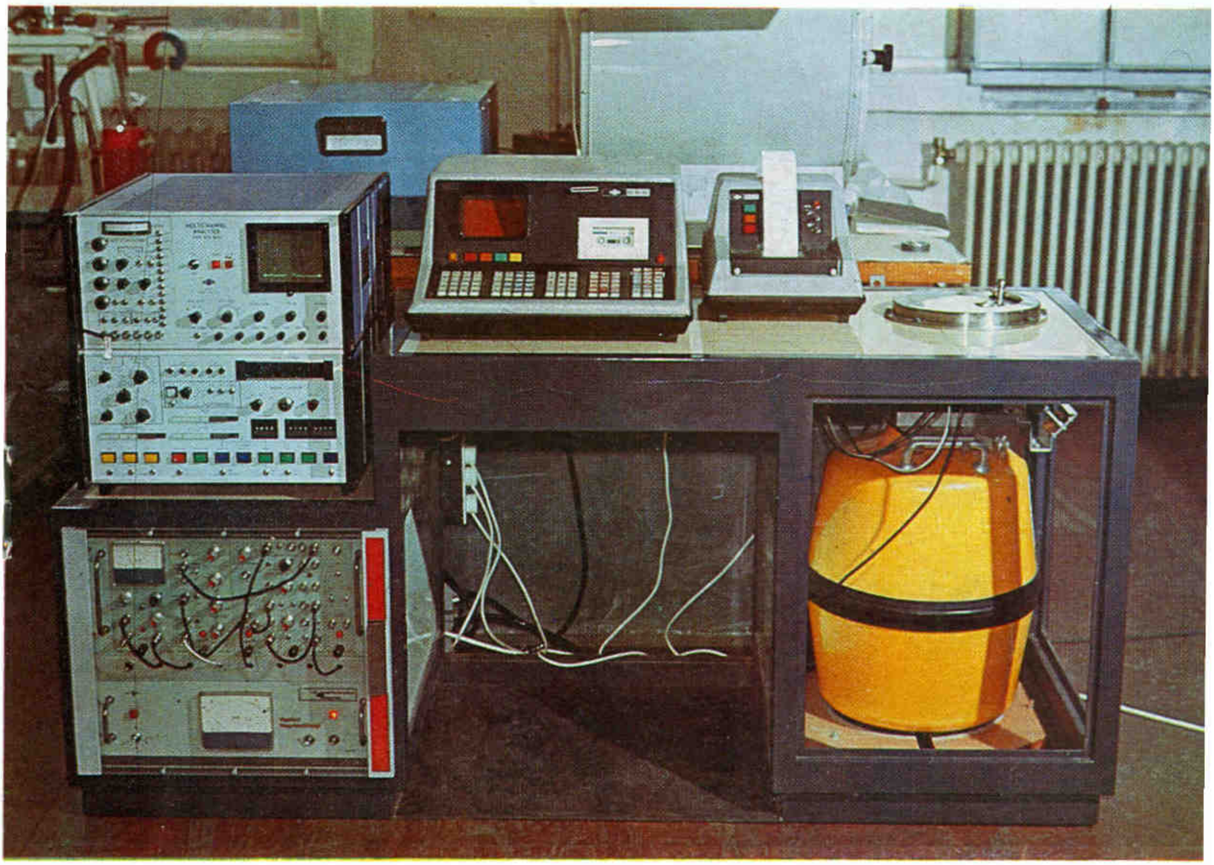
Instruments and methods developed in connection with nuclear research make possible to solve several special problems in chemical analysis.

The non-destructive determination of the $Z>11$ elements can be performed through X-ray fluorescence spectrometry. By using radioisotope X-ray excitation and a home-made Si(Li) spectrometer system, investigations have been carried out in several areas of applied inorganic analysis. By determining the microelement content of human tissues, the correlations between the microelement spectrum and some diseases are investigated. A study of the chemical composition of several archaeological finds of a single site enabled the grouping according to their origin. Methods have been developed to measure the pollution due to automobile exhausts and to determine the heavy metal content of natural waters, etc.

Using the high-energy protons of electrostatic accelerators for the excitation of the characteristic X-rays, analyses can be carried out on extremely small samples too. The techniques of PIXE-analysis are used in solving biomedical and environmental problems.

Several problems arising in gas phase chemical analysis can be solved by mass spectrometry. By the combination of a quadrupole mass spectrometer with a gas phase electron diffractograph used in molecule structure studies at the Central Institute for Chemical Research in Budapest, the actual composition of the molecules investigated in the gas phase has been determined.

The use of autoradiography techniques has long traditions in the Institute, especially in biomedical applications. Recently, by applying solid state track detectors, the diffusion of Th, U, Am and Cm in biological systems has been investigated. The transport of some boron compounds through biological membranes has been studied by induced radiography.



Instrument built for the Csepel Works to determine the composition of alloys

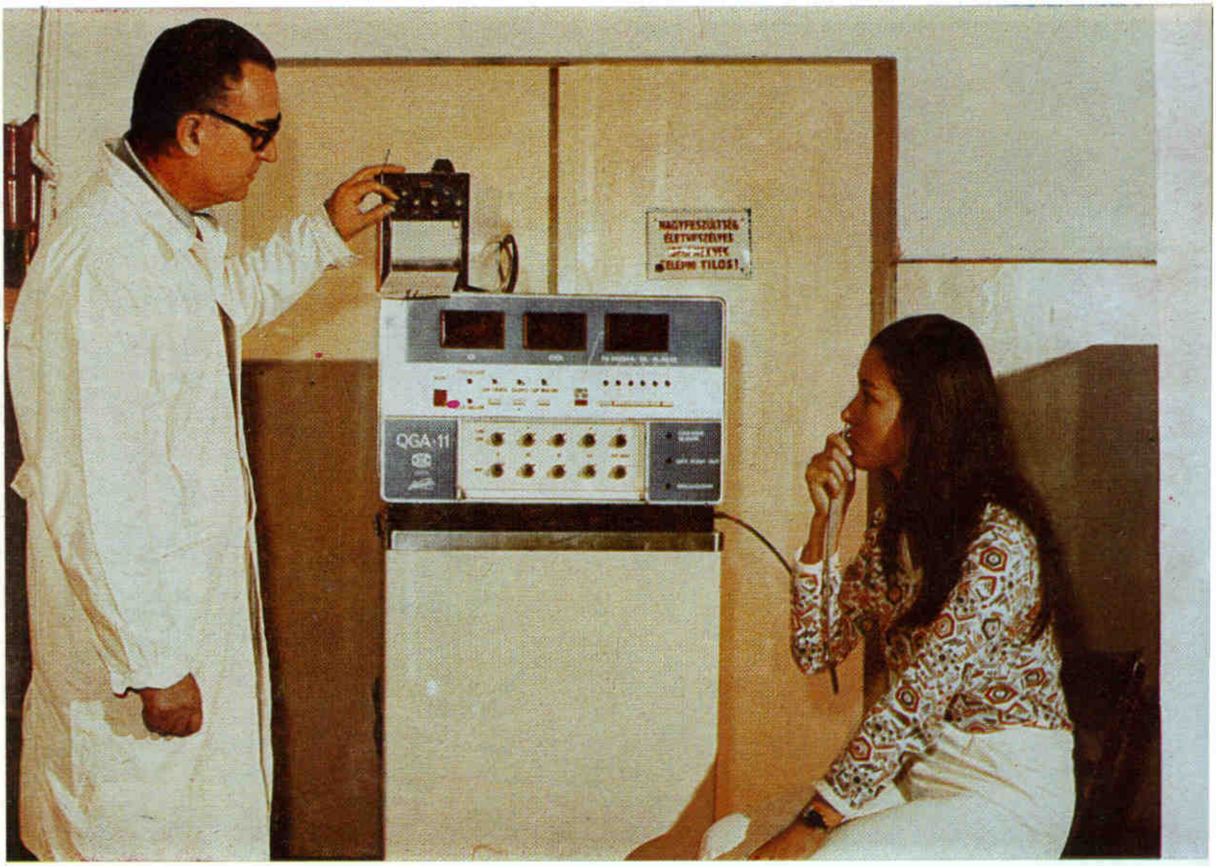
Research and development in methods and experimental techniques

From the very beginning a considerable amount of work has had to be devoted to developing equipment needed in research.

One of the first home-made instruments was a portable Geiger–Müller counter used by A. Szalay and his collaborators when they discovered the enrichment of uranium in some types of coal in Hungary.

Among the instruments of the early years, a toroid-sector beta-spectrometer based on an original principle[23] and a permanent-magnet band beta-spectrograph of high resolution with a working radius of 75 cm should be mentioned.

23 J. I. Horváth, Experientia 5 (1949) 112; A. Szalay and D. Berényi, Acta Phys. Hung. 10 (1959) 57; D. Berényi, Nucl. Instr. Meth. 23 (1963) 125

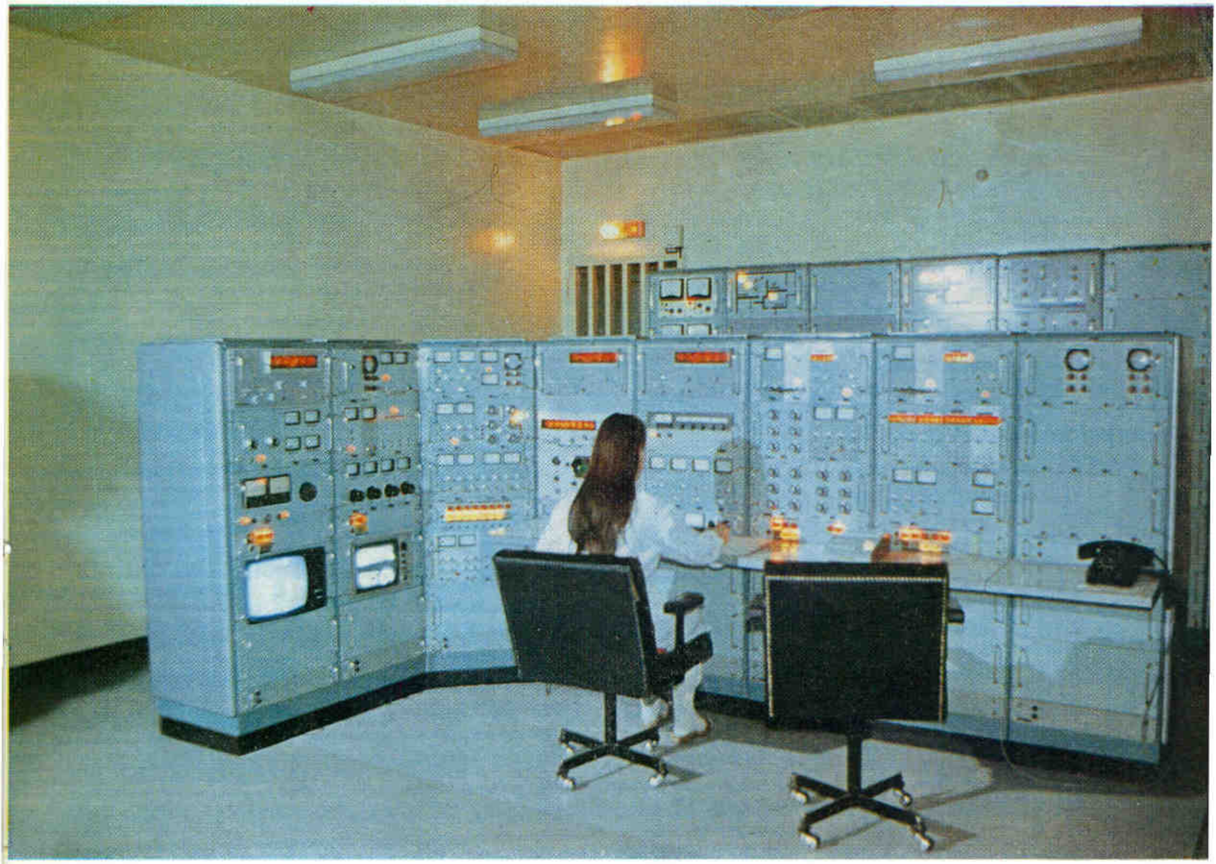


Quadrupole mass spectrometer as a medical gas analyser

Accelerators

All our accelerators, the two Van de Graaff generators (VdG-5 and VdG-1), the Cockroft–Walton generator and the neutron generator are home-made. The principles adopted in the construction of the VdG's constitute an advance in the *physics of accelerators*. The most remarkable of them are the choice of the proper electrode configuration to attain an optimum field uniformity near the high-voltage terminal[24] and the method of decreasing the amplitude of voltage surges following breakdowns[25]. The first electron-optical description and a detailed treatment of the aberrations of a new focussing and beam steering element, the asymmetrized quadrupole lens, were done by our scientists[26].

24 Á. Kiss, E. Koltay and A. Szalay, Nucl. Instr. Meth. 46 (1967) 130
25 Á. Kiss, Nucl. Instr. Meth. 92 (1971) 361
26 E. Koltay and Gy. Szabó, Nucl. Instr. Meth. 35 (1965) 88; Gy. Szabó, ibid., 125 (1975) 339



Control desk of the 5 MV Van de Graaff accelerator

The accelerating voltage of the VdG-1 is 0.3–1.5 MV. It is used for protons, alpha particles and light ions, with about 1 μA beam intensity and 1 keV energy resolution. The accelerating voltage of the VdG–5 is 0.8–5 MV. The intensity of the proton or alpha-particle beam is about 1–10 μA with an energy resolution of 1 keV. The energy is measured with a proton resonance magnetic field meter at the deflection magnet. The VdG–5 has five experimental channels, the data acquisition and processing are based on a Nuclear Data 50/50 system.

The accelerating voltage of the *Cockroft–Walton generator* is 100–700 kV. Proton, deuteron and electron beams can be produced with an intensity of 10 μA–1 mA and 800 eV energy resolution for positive ions.

The 150 kV *neutron generator* is used to produce 14 MeV (T+d) neutrons with a yield of about 10^{10} n/s. The generator is equipped with a fast pneumatic transport system.

A *cyclotron laboratory* is now in the course of planning. The laboratory which is due to start his work in 1985 will be equipped with a small, compact isochron cyclotron (U–103) having a pole diameter of 103 cm and developed in the USSR.

Detection techniques

Radiation detectors have been constructed in the Institute since its foundation. A notable result of the early years in the improvement of alkalihalide scintillators was the increase of their light yield by applying reflective coating on their surface[27].

Photoemulsion technique, traditional in the Institute, was applied e.g. in measuring the energy spectrum of the Po+Be neutron source[28]. In the last decade a number of results have been achieved in the development and application of the *solid-state track detector* technique. The finding that plastic track detectors can be used in fast neutron flux measurements[29] and the description of the track-etching kinetics[30] are the most remarkable of these. Recent experiments on visualizing the tracks with methods other than traditional etching are very promising. Besides methodical studies, extensive work is done in the application of the solid-state track detector technique in the broad fields of basic and applied research, in nuclear physics studies, neutron dosimetry, environmental research, etc.

To meet the requirements of nuclear spectroscopy and X-ray fluorescence analysis, *Si(Li) and surface barrier detectors* are made in the Institute. Si(Li) detectors are used in home-made X-ray emission analyzers. These instruments make the simultaneous and rapid determination of the concentration of the elements with $Z>11$ possible. The smallest detectable concentration is about 1 ppm or less.

Development of electron spectrometers

To meet the requirements of nuclear and atomic physics research done at the Institute, the necessity arose to develop several electron spectrometers fulfilling various needs. The line of electron spectrometers opened with the construction of magnetic spectrometers used in the study of radioactive isotopes. More recently, for studies in atomic collision processes and for low-energy photoelectron measurements including their application to ESCA-studies, a series of electrostatic electron spectrometers has been developed: ESA–11 for ESCA–studies; ESA–12 for nuclear spectroscopy work done at the Institute of Nuclear Research in Praha, ČSR; ESA–21: a spectrometer to measure the energy and angular distribution of electrons created in atomic collision processes.

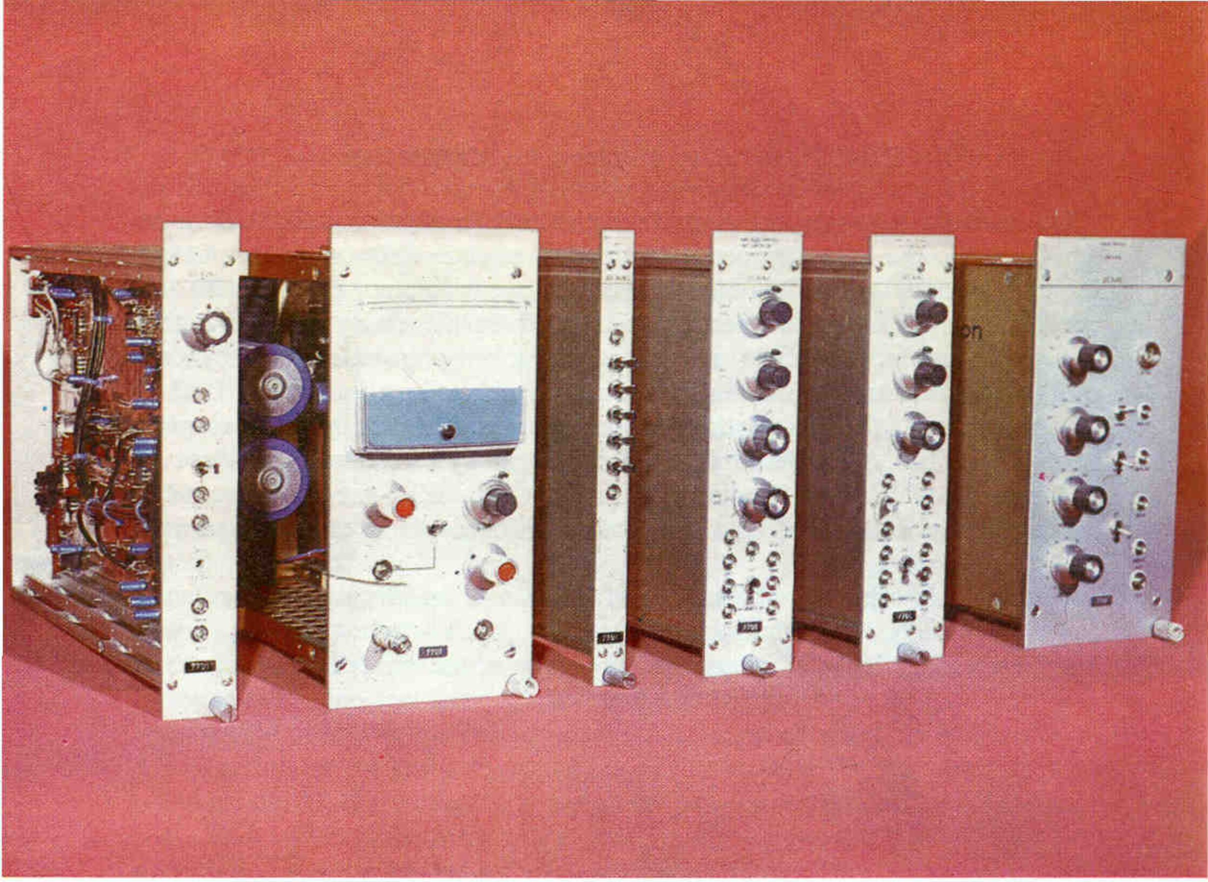
Most of the electron spectrometers possess a multi-purpose character. In the low-energy electrostatic spectrometer for ESCA-studies the investigated sample is excited by soft X-rays and the energy of the emitted photoelectrons is measured. This spectrometer, however, can be used not only for analysing atomic electrons, but also for beta-ray spectroscopy up to 25 kev beta energy with a resolution of 10^{-2}–10^{-4}. The measurements are controlled and the measured data are processed by a TPAi computer and a CAMAC system.

Vacuum technique and cryogenics

The vacuum technical group has developed oil diffusion pumps of various pumping speeds and an orbitron-type ion-getter pump to eliminate hydrocarbon contaminants. Several vacuum systems, some of which meet the requirements of ultrahigh vacuum technology, have been constructed. During the last decade a series of quadrupole mass spectrometers have been developed, including residual gas analysers as well as more advanced types for various purposes including a medical mass spectrometer for respiratory analysis.

The cryogenics group is engaged in developing cryostats for various purposes, in the development of superconducting quantum-interferometric devices ("SQUID") as well as in the application of the SQUID technique in various fields including the investigation of high-purity materials.

27 Gy. Máthé and R. Voszka, Nucl. Instr. Meth. 16 (1962) 335
28 L. Medveczky, Acta Phys. Hung. 6 (1956) 261
29 L. Medveczky and G. Somogyi, Proc. VI. Int. Conf. on Corpuscular Photography, Florence, CEPI Roma, 1967, p. 461
30 E. g.: G. Somogyi and A. S. Szalay, Nucl. Instr. Meth. 109 (1973) 211



Electronic modular units for nuclear measurements (CAMAC system)

Nuclear electronics

The nuclear electronic units of modular construction and developed in the Department of Nuclear Electronics are suitable for processing signals of nuclear detectors of various types, and meet the requirements of advanced nuclear spectroscopy work. A method of eliminating pile-up pulses was first developed in ATOMKI using the so-called zero-crossing pulse-shape discrimination[31]. This technique is also suitable for particle identification[32]. Several improvements in the spectroscopic parameters of the electronic units — most of which meet the requirements of the CAMAC system – have been patented.

31 Gy. Máthé, Nucl. Instr. Meth. 23 (1963) 261
32 Gy. Máthé and B. Schlenk, Nucl. Instr. Meth. 27 (1964) 10

Besides work in analogue signal processing techniques, work in digital electronics including the application of microprocessors has started during the last decade. Devices for special purposes including signal processors for X-ray analyzers, control- and data acquisition systems for mass spectrometers, etc. have been developed.

Technical background

In the development of instrumentation and in the implementation of the individual scientific projects the role of the skilled staff of the Technical Department (about thirty people) and the Department of Nuclear Electronics (about 25 members) is very important.

The research work is backed up by a small *computation group*. The Institute has besides several minicomputers a PDP 11/40 computer and access to a CDC 3300 in Budapest via a UT 200 user terminal.

Tracks of alpha particles in solid state track detectors. The tracks have been developed by a new technique worked out in ATOMKI

PDP 11/40 computer system

Practical application of scientific results

At the present level of scientific and technological development it is of particular importance to maintain direct links between pure scientific research and applied fields. An institute engaged in basic research has to seek for finding of utilizing the methods developed and putting the into practice. ATOMKI is qualified to promote the adaptation of nuclear methods in other fields of science and in broad areas of production by the tradition of interdisciplinary research and by the compelling need to construct a major part of its own equipment.

A review of applied research in this Institute was given in the previous sections, although not all the former activities of ATOMKI have been referred to. We only mention here the important role of ATOMKI in introducing radioisotopes into medical biology and clinical practice in this country. In addition, we should like to single out only a few examples of the numerous applications of potential use for society and the national economy.

First of all the work of Prof. A. Szalay and his collaborators is worth mentioning because it is a good example of the interrelation of pure and applied research from the pre-history of the Institute to the present. The discovery of the enrichment of uranium in some brown coals of Hungary was followed by the understanding of the mechanism of this enrichment having been caused by the sorption of uranium (and of some other microelements) on the humic acid content of fossile materials. The same mechanism has been recognized as being the cause of the microelement starvation of plants on peat soil, and appropriate methods have been worked out to counteract it.

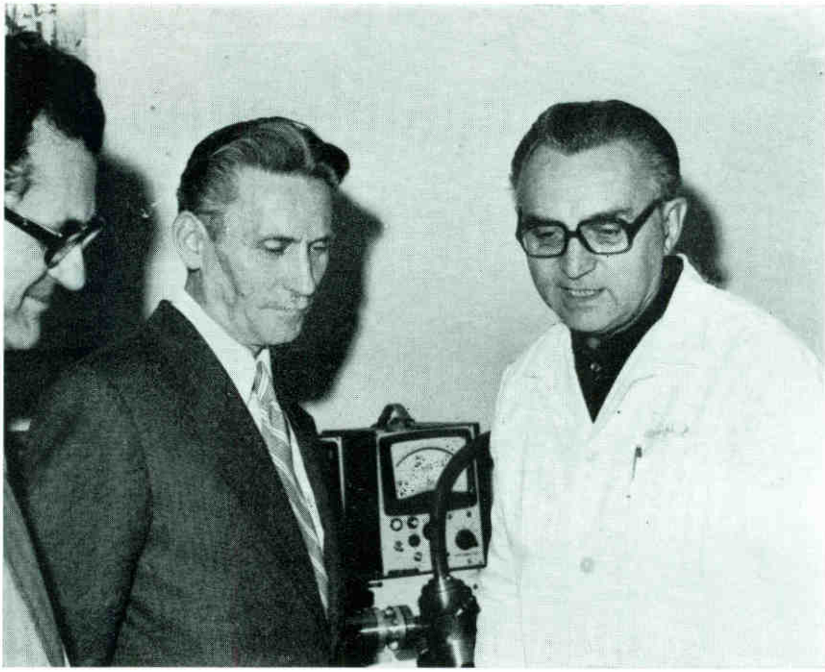
A family of basic *nuclear electronic* instruments, originally designed for internal use, have found a good market both in this country and abroad. Our instruments are used at several research and teaching organizations abroad, the laboratories of the first nuclear power plants in Czechoslovakia and in Hungary both are partly equipped with ATOMKI instruments. The production has been gradually increasing, and further extension of production was made possible through the cooperation with industrial firms.

The small quadrupole mass spectrometer originally designed for residual gas analysis has proved suitable for the analysis of exhaled air. Now it is produced by the MEDICOR Works as a medical instrument.

The most profitable application of nuclear techniques lies in *chemical analysis and material testing*. For example, X-ray fluorescence spectroscopy has been a tool that has been adapted by this Institute to special problems in industrial production, like the fast determination of calcium in bauxite, multi-element analysis of base metal alloys, etc. Analyses are performed for customers and instruments for their specific needs are constructed. The techniques of X-ray fluorescence analysis show great promise for further application in raw material research, food testing, in the metal industry etc.

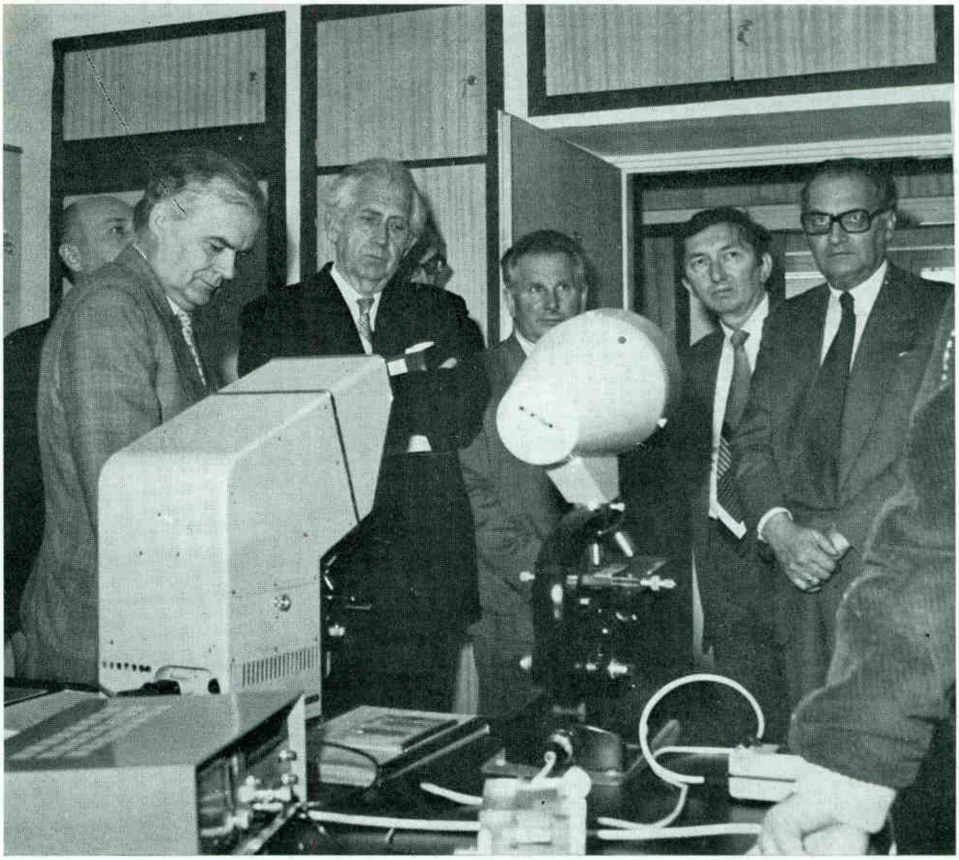
The versatile method of electron spectroscopy has been adapted to chemical analysis. This technique is useful in the study of the chemical structure of thin surface layers, and is being applied in several fields of materials research.

Partnerships in sponsored RD activities



Prime Minister Gy. Lázár in the Institute

Secretary General of the International Atomic Energy Agency visiting the Institute



The visit of the President and the Secretary General of the Hungarian Academy of Sciences in ATOMKI

◀ *Participants of the Conference on Ion-Atom Collisions held in 1981*

External contacts, cooperation

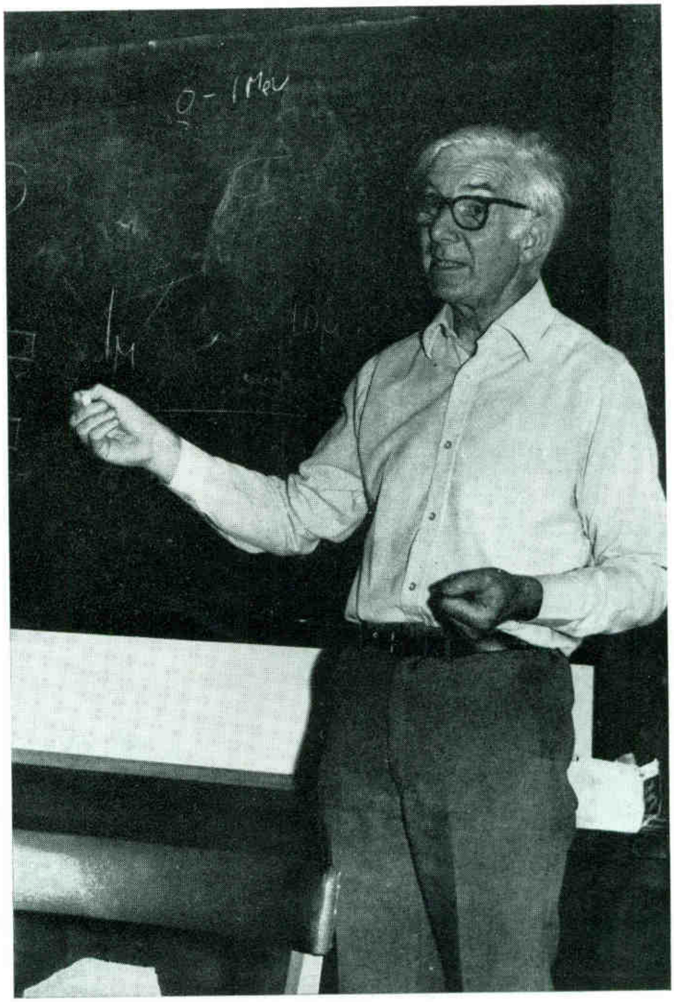
ATOMKI realizes the importance of maintaining and strengthening relations with other laboratories, scientific and social organizations, and of taking an active part in the social and economic life of this country.

From among the home institutions, the Central Research Institute for Physics, Budapest; the Institute for Experimental Physics, Kossuth University, Debrecen; the School of Medicine in Debrecen and more recently, the University for Agriculture, Debrecen have been our most frequent partners. Numerous joint projects have been done in collaboration with the Joint Institute for Nuclear Research, Dubna, the Nuclear Physics Laboratory, Oxford, the Yoffe Institute, Leningrad, the Physics Laboratory, University of Utrecht, the Institute of Chemical Research, Kyoto University, the Institute of Nuclear Physics, University of Frankfurt a. M., etc. The Institute acknowledges the most valuable aid of the institutes which have received its members, and visiting scientists are always welcome to ATOMKI.

Several scientific meetings have been organized by ATOMKI. A significant meeting was the *International Conference on Electron Capture and Higher Order Processes in Nuclear Decays* in 1968. A successful international conference was held in 1981 on *ion-atom collision processes*.

ATOMKI has members on a number of international bodies such as the International Nuclear Data Committee (IAEA), editorial boards of several international journals, the Scientific Council and special committees of the Joint Institute for Nuclear Research, Dubna, etc. Prof. A. Szalay is a doctor honoris causa of the Marie Skłodowska-Curie University of Lublin. Leading scientists of ATOMKI participate in various scientific commissions of the Hungarian Academy of Sciences, Roland Eötvös Physical Society of Hungary, the National Atomic Energy Commission of Hungary, etc.

ATOMKI participates in various kinds of training activity. Members of the staff give special courses at Kossuth University, act as supervisors for undergraduate dissertations, and the Institute grants fellowships to postgraduates. Furthermore, a modest fellowship is offered to school-teachers who join in research work. A great number of scientists from developing countries have studied and obtained scientific degrees here. ATOMKI is open to academic people interested in research related to that of the Institute. They have the opportunity to join as research guests, use the library, computers, all the institute's research facilities.



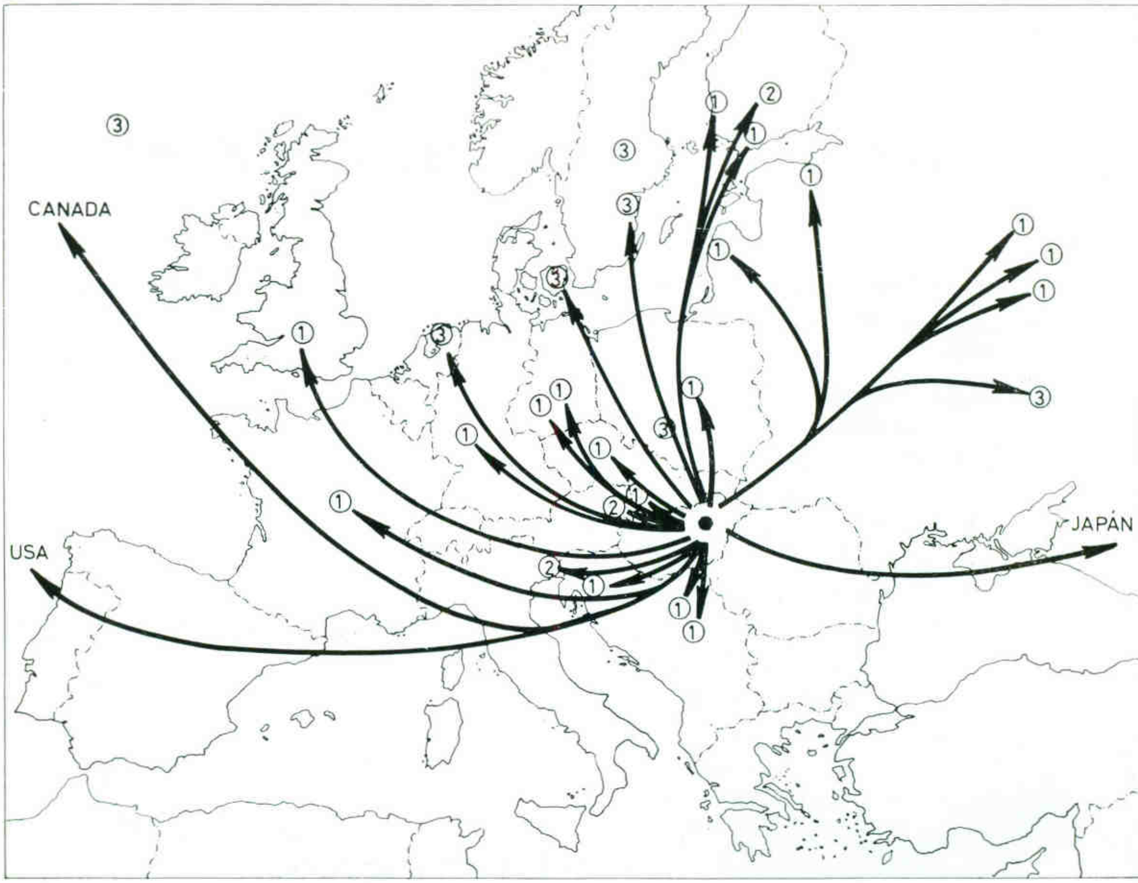
Prof. S. W. Lawson lecturing in ATOMKI

Lecture of Acad. Z. A. Zeldowich

Organization of the scientific and technical staff

Director: *Prof. D. Berényi,* Corr. Member of the Hung. Academy of Sciences
Scientific deputy director: *Dr. B. Schlenk,* CSc

1. Department of Nuclear Methods
   Head: *Dr. G. Somogyi,* CSc
2. Department of Electrostatic Accelerators
   Head: *Prof. E. Koltay,* DSc
3. Department of Nuclear Electronics
   Head: *Dr. Gy. Máthé,* CSc
4. Department of Nuclear Atomic Physics
   Head: *Prof. D. Berényi,* Corr. Member of the Hung. Academy of Sciences
5. Department of Technical Physics
   Head: *Dr. I. Berecz,* CSc
6. Cyclotron Department
   Head: *Dr. A. Valek,* CSc
7. Group of Atomic Collisions
   Head: *Dr. B. Schlenk,* CSc
8. Group for Theoretical Nuclear Physics and Computation
   Head: *Dr. B. Gyarmati,* CSc
9. Group for Interdisciplinary Research
   Head: *Prof. A. Szalay,* Member of the Hung. Academy of Sciences
10. Group for Nuclear Spectroscopy
    Head: *Prof. T. Fényes,* DSc
11. Group for Scientific Documentation
    Head: *Dr. L. Medveczky,* DSc
12. Technical Department
    Head: *I. Dombi,* chief engineer
13. Financial Department
    Head: *Dr. Gy. Kovács,* deputy director for financial matters



International contacts in scientific cooperation
1: Cooperation based on bilateral agreements 2: Regular cooperation
3: Other scientific contacts

General information

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Cables: ATOMKI DEBRECEN
Telex: 72210 atom h
Telephone: (52) 17–266
Founded: July 1, 1954
Staff: near 300 permanent staff members (about 100 research workers), visiting scientists, students
Atomki Bulletin: The Institute issues the quarterly ATOMKI Közlemények (ATOMKI Bulletin). It is published in Hungarian, English and Russian. Please contact the library for additional information.

Felelős kiadó: dr. Berényi Dénes, az ATOMKI igazgatója
Szerkesztette: dr. Kovách Ádám
A kézirat nyomdába adásának ideje: 1981 október
Készült a Kner Nyomdában, Gyomán