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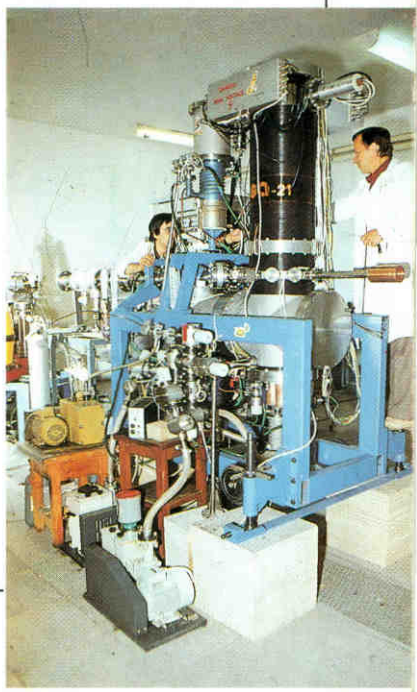


Front cover: Electrostatic electron spectrometer for ion-atom collision studies

Institute of Nuclear Research of the Hungarian Academy of Sciences

Debrecen
1987

INTRODUCTION

The Institute of Nuclear Research of the Hungarian Academy of Sciences, Debrecen, (ATOMKI) was established in 1954 with the principal aims to conduct research in fundamental nuclear physics, to develop equipment for such purposes, as well as to apply nuclear techniques in other branches of science and in solving specific problems of practical importance.

The nucleus of the scientific staff was recruited from the Institute of Experimental Physics of Kossuth University, Debrecen, where pioneering work in experimental nuclear physics in Hungary was initiated by Prof. A. Szalay, founding director of ATOMKI, as early as in the second half of the thirties. The characteristics and traditions of the Debrecen scientific school of nuclear physics giving equal emphasis to basic and applied research have been shapeforming in the science policy of ATOMKI, a careful balance being maintained between basic nuclear and modern atomic physics studies, interdisciplinary research and the application of scientific results, the three main and harmoniously interrelated fields of present activities. The characteristically experimental approach of the Debrecen scientific school of physics also traces back in its traditions to physics education for over four centuries in the old Reformed College, regarded as the ancestor of university education in Debrecen.

The Institute maintains traditionally good relations with higher and secondary teaching organizations in and around Debrecen by handing on to a younger generation the intellectual inheritance accumulated during the decades of its history. This also provides ATOMKI with a chance to select the most promising young people for would-be members of the institute, a practice followed from the early years on. This made the institute well known not only as one of the major research centres of the country but also a workshop of

skilled and practical-minded physicists who are willing to use their skills and facilities for the benefit of such diverse areas as physics, chemistry, agriculture, earth sciences, medicine and industry.

This booklet is intended to give an illustration of the scope and character of work going on in this institute.

The first steps in experimental nuclear physics – the Institute's museum

CURRENT RESEARCH ACTIVITIES

Nuclear and Atomic Physics Research

Basic nuclear studies belong to the traditional fields of research in ATOMKI. Although its means and facilities are rather limited, the careful choice of research topics requiring relatively modest instrumentation but much effort and inventiveness has helped in obtaining results which formed the sound base of the institute's present reputation, and showed the way in which a relatively small research centre with modest facilities might keep pace with the challenge of progress in science nowadays. The early demonstration of the recoil effect of the neutrino in the beta-decay of ^{6}He, results in beta-ray spectroscopy and in the study of electron capture phenomena are examples of this kind.

Current nuclear studies are based mainly on the accelerator facilities of the institute, and include studies on nuclear structure and reaction mechanism as well. *Experimental*

The main building of the Institute

nuclear reaction studies include the application of charged particle and gamma-ray spectrometry in the structural study of light nuclei; in-beam nuclear spectroscopy involving gamma ray and conversion electron studies on medium Z nuclei; as well as the investigation of optical model parameters at low energies in heavy nuclei. *Theoretical nuclear physics studies* are aimed at the investigation of effective nucleon-nucleon interaction in the advanced cluster model of nuclei; at the study of giant resonances in pair interactions and at the investigation of Gamow states. Current studies include also the interpretation of experimental nuclear data within the frames of the interacting boson-fermion model.

The extensive use of experience gained in basic nuclear research, as well as the equipment and techniques of nuclear physics contributed to the development of atomic physics oriented research. Current research in the *investigation of ion-atom collisions* encompasses on-line accelerator studies of inner shell ionization phenomena under light ion impact with the determination K, L, M subshell ionization cross sections, L-shell alignment studies, investigations concerning the effects of multiple ionization, etc. Extensive international cooperation has been developed in the investigation of Auger electron spectra from high energy collisions involving light and medium weight collision systems. On the other hand, the study of electron capture and electron loss phenomena in simple structured collision systems at moderate energies is aimed at the study of basic phenomena in ion-atom interactions. Experiments are supported by corresponding theorecal studies and the development of up to date electron spectrometer systems.

Building of the cyclotron laboratory (1985)

Materials Research and Interdisciplinary Studies

Although the shapegiving research area of ATOMKI 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 physics research and instrument construction found its way to applications in quite a number of fields of basic and applied interest in the various areas of physics, chemistry, agriculture, the earth sciences as well as of medical, biological and environmental research.

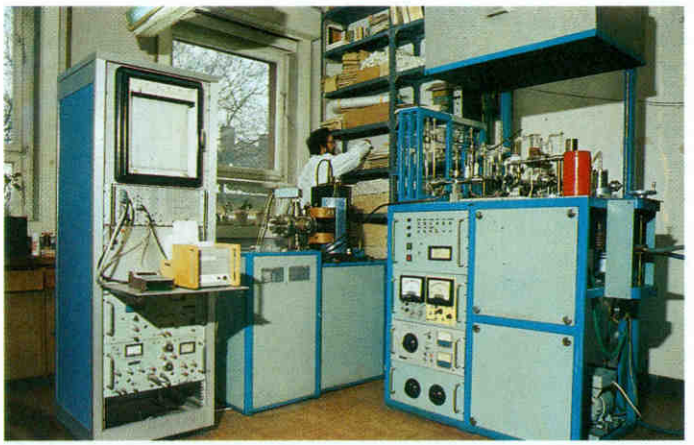
A wide range of *accelerator-based techniques of chemical microanalysis* has been developed and used in solving trace analytical tasks on an extended interdisciplinary scale. Methods applied presently and based on the use of a small cyclotron and VdG accelerators include proton induced X-ray analysis (PIXE), prompt gamma-ray and charged particle activation analysis (PIGE, CPAA); charged particle scattering techniques (RBS, FAST, etc.) as well as neutron activation analysis. These techniques form the base of extended collaboration with other reserach institutions and industrial enterprises, offering excellent means to solve special analytical problems of practical interest as well.

Researches in *laboratory X-ray fluorescence analysis* employing semiconductor detectors and radioisotope X-ray excitation include studies concerning the matrix effect in XRF analysis as well as applications in metallurgy, archaeology, environmental research, etc.

Studies in *applied solid state and surface research* include surface and near-surface analysis by electron spectrometry under X-ray excitation (ESCA-studies), the kinetic spectra of photoelectrons carrying information on the chemical struc-

ture of the surface layers of the material under bombardment. ESCA-techniques are being used in the study of corrosion phenomena as well as in the surface study of catalysts and other materials. The study of electrical properties of materials under low temperature conditions (liquid He) and using a superconducting quantum-interferometer (SQUID) allows to draw conclusions on trace impurities in high-grade metallic substances.

Studies in the earth sciences have been carried out from the early years on and started with the discovery of heavy metal enrichment in some coals in Hungary as the result of ion exchange on humic substances. Current researches include extensive work in geochronology by potassium-argon and rubidium-strontium dating, as well as ^{14}C chronological studies. Isotopic studies on light elements (C, O, N, S) started recently. The use of the high sensitivity magnetometric methods of superconducting quantum-interferometry enables the study of geomagnetic problems as well. A high-sensitivity microgravimeter based on cryogenic principles in under construction and will be used in the study of time variations in gravity.



K-Ar geochronological laboratory

Investigations of biomedical character—besides the extensive use of the analytical techniques already mentioned—include the use of SQUID-s in the study of biomagnetic phenomena (e.g. magnetocardiography). The cyclotron facility of ATOMKI is also used to produce several positron-emitting isotopes for medical purposes, provisions having been made for the on-site use of the short-lived ones in medical diagnostics.

Instrumental Research and Development

From the very beginning a considerable amount of work has been devoted to developing equipment and special techniques needed in research. In accordance with the traditions of the Debrecen school of nuclear physics, instrumental research and the development of advanced measuring techniques gains equal appreciation with successful work in basic research.

The electrostatic accelerators (VdG–1 and VdG–5) of ATOMKI for example, as well as the Cockroft-Walton accelerator are home-made. The principles adopted in the VdG's constitute and advance in *accelerator physics*. Current studies in this field are concentrated on beam diagnostics and on the use of advanced beam handling techniques at the cyclotron and the electrostatic accelerators. Alternative plans are being made in connection with the further development and future use of the institute's accelerators.

Developments in particle detectors, detection systems and techniques constitute traditional and successful fields of development work in ATOMKI. Semiconductor detector studies are carried out in order to develop high-resolution X-ray and charged particle detectors, in close connection with the development of high-quality measuring systems for analytical purposes and general laboratory use.

In parallel with their extensive use in different interdisciplinary fields, work appreciated on a world scale is done in the study of solid state nuclear track detectors and track visualizing techniques.

Studies in vacuum physics and applied gas analysis are concentrated mainly in the field of developing up to date quadrupole mass spectrometers and measuring systems for various purposes, including industrial applications. Considerable

interest has been evoked by recent developments at ATOMKI which enable to measure concentrations of gases dissolved in fluids as well. In parallel with QMS development, the development of components and systems for UHV purposes is also in progress.

Work in *nuclear electronics* include the design and development of high-quality modular instrumentation with increased time- and energy resolution (CAMAC and NIM systems), as well as the development of electronic instrumentation, data acquisiton and data handling systems for specific research purposes.

The extensive use of electron spectrometry in several laboratories of ATOMKI is supported by the *design and development of electrostatic electron spectrometers* for various purposes and based on novel design principles.

Equipment testing in the Department of Nuclear Electronics

MAIN RESEARCH FACILITIES

MGC-20E cyclotron

— beams available:

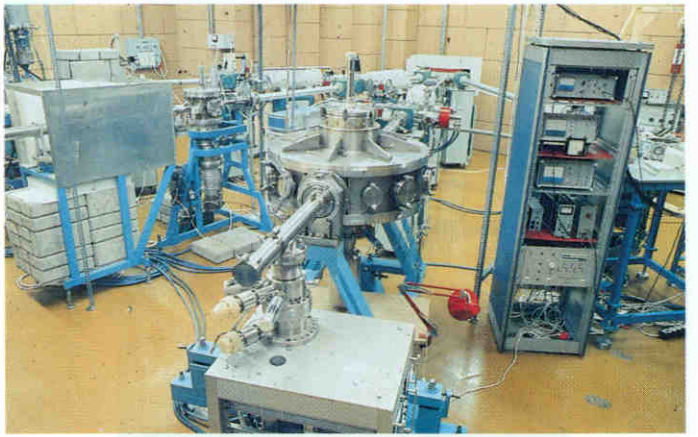
H^+	2–20 MeV	50 μA
D^+	1–10 MeV	50 μA
$^3He^{++}$	4–26 MeV	25 μA
$^4He^{++}$	2–20 MeV	25 μA

— energy stability: 0.3% (0.1% after analysing magnet)
— number of beam channels: 11 (5 after analysing magnet)
— specific instrumentation at the individual channels available at present: on-beam electron spectrometer for ion-atom collision studies, facilities for analytical use, in-beam nuclear spectroscopy instrumentation including a superconducting magnet conversion electron spectrometer, Be and D neutron sources, isotope production facilities, etc.

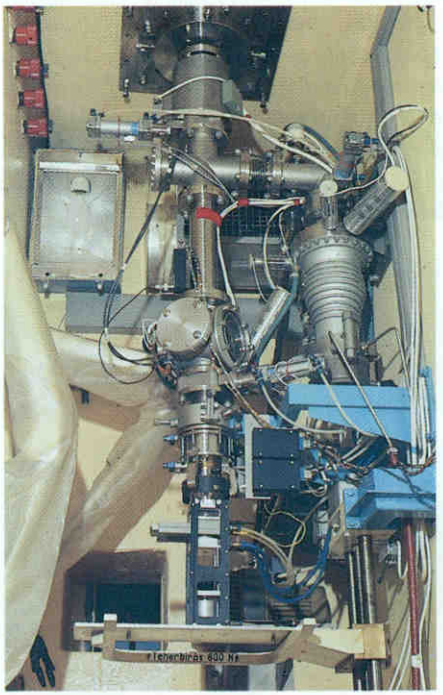
The cyclotron laboratory has an own measuring centre based on a TPA 11440 computer and a CAMAC system for data acquisition.

The MGC-20E cyclotron

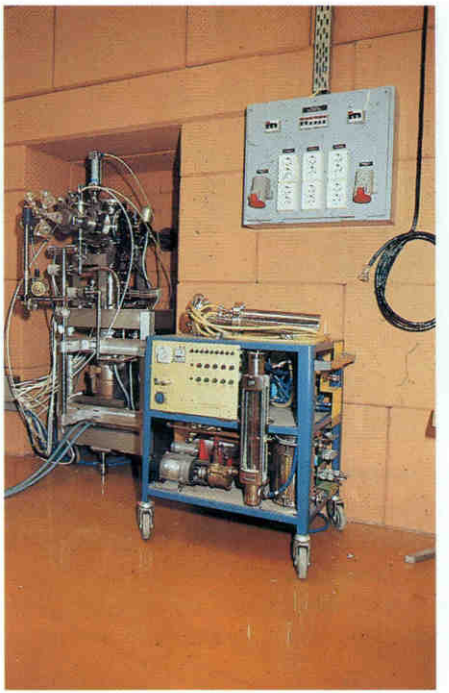
Beam channels of the cyclotron



Main target area of the cyclotron laboratory

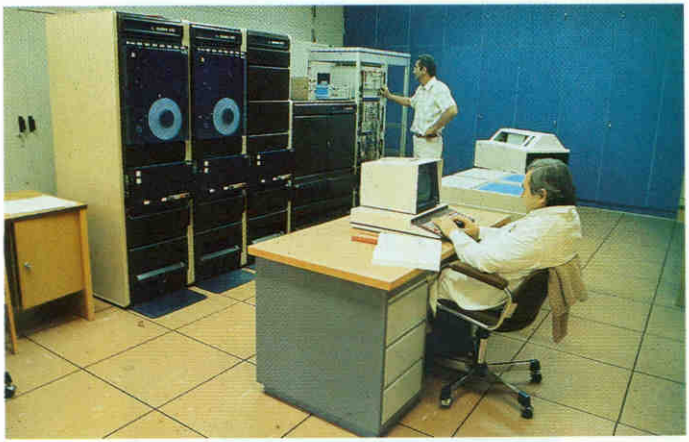


Target assembly for isotope production

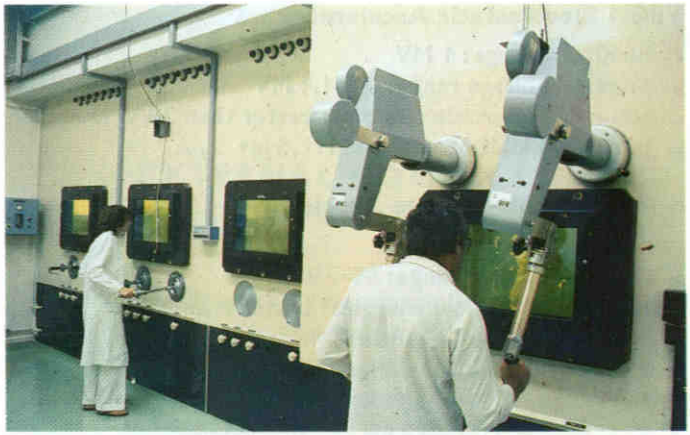


Low-background target area for nuclear spectroscopy measurements

Control desk of the cyclotron



Computer centre of the cyclotron laboratory



Radiochemical laboratory

VdG-5 Electrostatic Accelerator

- nominal voltage: 5 MV
- practical voltage range: 0.5–4.8 MV
- accuracy of particle energies: better than 1 kV
- beams available at present:

H^+	10 μA
$^1He^+$, $^1He^+$	20 μA
C^+, N^+, O^+ Ne^+	1–2 μA

  For the heavier ions beams with higher ionizations states produced by electron stripping are available.
- number of beam channels: 5
- specific instrumentation available at present are facilities for charged particle spectroscopy, facilities for PIXE analysis, low-background gamma spectrometry, instrumentation for ion-atom collision studies. The data center of the accelerator is based on a Nuclear Data 50/50 system with direct data transfer to the institute's central computing facilities.

VdG-1 Electrostatic Accelerator

- nominal voltage: 1 MV
- practical voltage range: 0.2–1.4 MV
- accuracy of particle energies: better than 2 kV
- beams available at present: H^+, He^+ 5 μA

K-800 Cockroft-Walton Accelerator

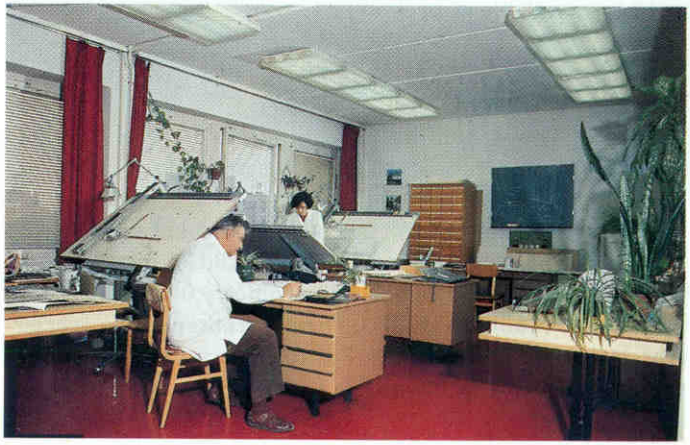
- nominal voltage: 800 kV
- practical voltage range: 60–750 kV
- accuracy of particle energies: better than 0.5 kV
- beams available at present in a single beam channel equipped with a 90° deflecting magnet:

H^+	30 μA	D^+	20 μA
He^+	10 μA	e^-	80 μA

Library

The Institute owns a library with about 50.000 library units, the number of books being approximately 13.000. About 400 journals and periodicals are received regularly, some of them on an exchange basis. Outside the library of the institute, the libraries of Kossuth University, Debrecen are at the disposal of staff members and guests as well.

Library services include interlibrary loan services both on a home and international scale.



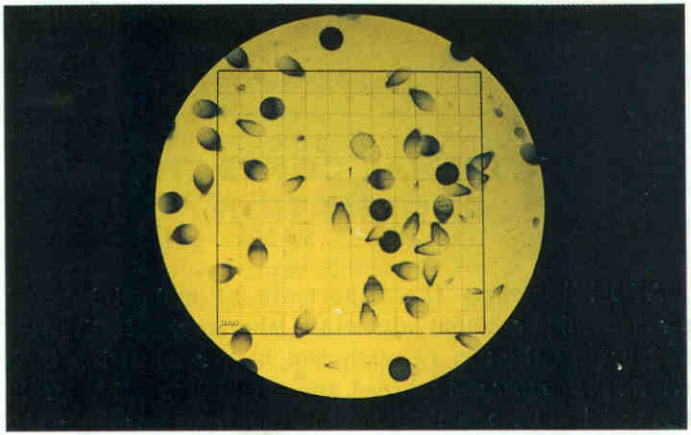
Equipment planning in the Department of Technology

EXTERNAL CONTACTS, COOPERATION

ATOMKI realizes the importance of maintaining and strengthening relations with other laboratories, institutions and organizations of research and higher education both within the country and abroad, and of taking an active part in the social and economic life of the country, according to its possibilities. Regular contacts including the participation in joint research projects are maintained with institutions and laboratories in about twenty countries all over the world. The institute also contributes to the promotion of international cooperation by the regular organization of conferences, symposia and workshop meetings of international character.

Contacts with the economic and industrial sphere are realized within the frames of cooperative development work and industry sponsored R&D activities. Some equipment and instruments developed in the institute are available for customers both in the country and abroad.

ATOMKI participates in various kinds of training activites. It takes part in the training programmes of the IAEA by sending experts and receiving trainees within the frames of the Agency's programmes. Members of the staff give special courses at Kossuth University, act as supervisors for undergraduate theses and postgraduate work. Furthermore, temporary part-time fellowships are offered to school-teachers who want to join in research work for a time. In general, ATOMKI is open to academic people interested in research related to that of the institute.



Nuclear tracks in the MA-ND type nuclear track detector developed in cooperation with the Hungarian Optical Works

DIGITRACK – equipment for the evaluation of nuclear track detectors

ORGANIZATION OF THE SCIENTIFIC STAFF

Director: *Prof. D. Berényi*, Member of the Hung. Academy of Sci.

Scientific deputy directors: *Prof. E. Koltay*, DSc
Dr. D. Varga, CSc

1. Department of Nuclear Spectroscopy
2. Department of Nuclear Reactions
3. Department of Accelerator Development and Applications
4. Department of Theoretical Physics
5. Department of Nuclear Atomic Physics
6. Department for the Development and Application of Particle Detectors
7. Department for Cyclotron Applications
8. Department of Vacuum Physics
9. Department for Isotope Analysis
10. Department of Nuclear Electronics
11. Cyclotron Department
12. Group for Electron Spectroscopy and Applications
13. Group for Cryogenics
14. Group for Interdisciplinary Research

GENERAL INFORMATION

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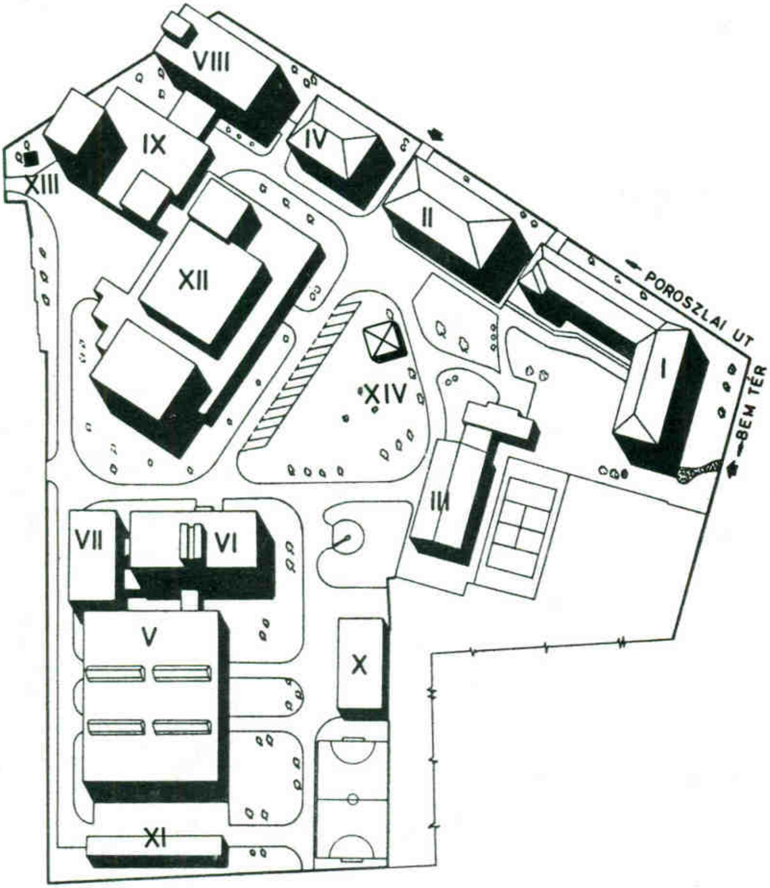
Founded: July 1, 1954
Staff: approx. 300 permanent staff members (about 100 scientists), visiting scientists, students.
ATOMKI Bulletin: The Institute issues the quarterly report "ATOMKI Közlemények„ (ATOMKI Bulletin). It is published in Hungarian, English and Russian. Please contact the library for additional information.

The library

Felelős kiadó: dr. Berényi Dénes, az ATOMKI igazgatója
Szerkesztette: dr. Kovách Ádám
Készült a Kner Nyomdában Gyomaendrődön, 1987-ben



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