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Booklet of abstracts

This booklet contains the abstracts of the works submitted for oral presentation at the Technical Meeting on Novel Applications of Accelerator-based Techniques for Socio-economic Benefits organized by the IAEA Physics Section of the Division of Physical and Chemical Sciences, Department of Nuclear Sciences and Applications of the International Atomic Energy Agency (IAEA) in Vienna, Austria on 1–3 October 2024. The abstracts are listed in alphabetic order of the name of the lAEA Member States represented in the Technical Meeting

Prepared by
Sotirios Charisopoulos, IAEA, Physics Section, Division of Physical and Chemical Sciences (Scientific Secretary)

Modernization of the 3.75 MV Van de Graaff accelerator facility of Algiers Nuclear Research Center: Progress and challenges

Khaled Belhout

Algiers Nuclear Research Center, Boulevard Frantz Fanon, Algiers, Algeria

The CRNA's Van de Graaff model KN 3 MV accelerator, installed in 1959 and upgraded in 1976 to 3.75 MV has been used for atomic and nuclear physics studies, as well as for different applications using accelerated ion beams. In the last two years, a program of modernization of the Van de Graaff accelerator was taken.

The old high voltage power supply was replaced by a new one, the corona current stabilization system was partially modernized. The beam lines, the analyzing magnet and the reaction chambers was completely dismounted, cleaned then realigned and reassembled. The vacuum system was fully inspected, and the bad parts replaced with new ones. The focus power supply was completely rebuilt with new semiconductor components. Installation of TANGO Control system for control and monitoring of different accelerator parameters.

The work was planned to be in incremental and iterative steps, this allows a time allocation for the users and carful planification of the next steps of modernization.

All these works aimed to transform the Van de Graaff accelerator in a reliable tool for R&D and IBA applications.

Upgrades at the Tandem Accelerator Facility at the Ruđer Bošković Institute

D. Cosic, Z. Siketić, S. Fazinić, and M. Jakšić
Ruder Boskovic Institute (RBI), Bijenicka cesta 54, 10 000 Zagreb, Croatia

The RBI Tandem Accelerator Facility is managed by the Division of Experimental Physics through its Laboratory for Ion Beam Interactions. The ongoing Facility upgrade includes the construction of a new building and the installation of a 5 MV Tandem Accelerator. With the construction of the new building underway, current efforts in the Laboratory for Ion Beam Interactions are focused on optimizing the internal layout and developing a unified control system. This upgrade has been guided by over 30 years of experience in operating a medium-sized accelerator facility and by leveraging modern technologies standardized across similar facilities.

The layout of all facility instrumentation is being meticulously planned using 3D modeling software to accurately define the space required for the accelerator, auxiliary equipment, and beamline end stations. This computer-aided design (CAD) model is continuously updated and validated through ion beam optics simulations, ensuring optimal use of space and efficient cable routing between instruments.

Moreover, the rapid advancement of technology and the increasing complexity of experiments over the past 30 years highlighted the limitations of the current control system, which struggled to keep pace. To address this, significant time and resources have been dedicated to developing a new control system capable of evolving with future laboratory needs. After careful consideration, the Experimental Physics and Industrial Control System (EPICS) was selected for the upgrade. This upgrade represents an excellent opportunity to completely overhaul the control system. Importantly, the existing laboratory has served as a critical resource for learning, testing, and implementing various aspects of the new system, providing the necessary expertise and confidence to transition to EPICS.

By combining lessons learned from the current facility configuration, best practices from other facilities, and modern software tools, we have developed a comprehensive plan for upgrading the RBI Tandem Accelerator Facility. This plan gives us confidence that the upgrade can be executed within the shortest possible timeframe.

Practical activities at the cyclotron facility of EAEA

H. Ebrahim Elmetwally
Experimental Nuclear Physics Department, Nuclear Research Center,
Egyptian Atomic Energy Authority (EAEA), Cairo, Egypt

The cyclotron complex of the Egyptian Atomic Energy Authority was dedicated for several research and technological directions by using the Russian type MGC-20 medium energy cyclotron (18 MeV) through a TC project with the IAEA. The cooperation with several research groups worldwide started early which allowed collecting the required knowledge of accelerator technology and assisted the operation and maintenance teams. The activity of the cyclotron group focused on the experiments on measurements of nuclear reactions data and accelerator-based neutron activation. Based on this experience, the end stations were developed for multipurpose irradiation. There were several attempts for modernizations of the cyclotron operation system and its RF components. The irradiation units and the surrounding laboratories were organized for further scientific and training activities.

The cyclotron facility receives about 150 undergraduate students annually in addition to the master and Ph.D. students from different universities. Recently, the operation stopped due to a technical problem which is now under investigation by local experts. The facility was also equipped with 3 MV tandem electrostatic accelerator, which is coupled with end stations for ion beam analysis. Some of the previous and current efforts as well as the recent difficulties facing the facility will be presented.

Establishment of the Ghana Pelletron Accelerator Facility for Sustainable National Development - Successes, Challenges and Lessons learnt.

[1,2] Nuviadenu Christian, [1,2] Forson Amos, [1,2] Tandoh Joseph, [1,2] Ahiamadjie Hyacinthe, [1] Sackey Henry, [1] Quashigah Godfred, [1,2] Godsway Banini and [1,2] Emmanuel Gazoya

[1]Accelerator Research Centre, National Nuclear Research Institute, Ghana Atomic Energy Commission

[2] School of Nuclear and Allied Sciences, University of Ghana, Legon.

The Accelerator Research Centre (ARC), established within the National Nuclear Research Institute of the Ghana Atomic Energy Commission (GAEC), was conceived as a central laboratory to support education, training, research, and development. The primary use of the accelerator is for Ion Beam Analysis techniques to analyse materials relevant to health, agriculture, mining, the environment, art and cultural heritage, and forensics.

In 2004, Ghana approached the International Atomic Energy Agency (IAEA) with the concept of establishing an accelerator facility. A Technical Cooperation Project (TC Project) proposal was submitted and got approved. Through IAEA facilitation, the Government of the Netherlands donated a 1.7MV Pelletron Accelerator, which was in storage at Vrije University of Amsterdam, to Ghana. In 2012, the accelerator was refurbished at the Kernfysisch Versneller Instituut (KVI) at the University of Groningen by a team of experts. During the refurbishment, five Ghanaian scientists and engineers received training.

Between 2008 and 2014, under the TC Project, the IAEA sponsored fellowship training and PhD sandwich programs in accelerator technology for Ghanaian scientists and engineers in South Africa, Italy, and the Netherlands. These trained individuals now serve as key staff members of the facility.

The accelerator facility was commissioned in March 2016 and is currently used to provide analytical services to end-users, train university students, and conduct other research and development activities despite occasional component breakdowns.

Ghana, in collaboration with the IAEA, is currently implementing a new TC Project for the period 2022–2025 to upgrade the Accelerator Facility with the addition of a new ion source and an external beamline. The upgraded facility will enhance services provided to accelerator end-users.

This presentation showcases the successes and challenges encountered since the establishment of the Accelerator Facility, along with key experiences and lessons learned.

Experience of small and medium scale Proton and Heavy Ion Accelerator Facilities

Arun Agarwal and Rajesh Kumar
IADD, MRG Bhabha Atomic Research Centre, Trombay, Mumbai - 400 085 India.

Bhabha Atomic Research Centre is a premier multidisciplinary research institute of INDIA. One of the key elements of research and development activities at BARC is design, development and execution of particle accelerators. These particle accelerators are used for research in the field of basic sciences such as physics, chemistry, biology or material science and societal application such as production of radioisotopes for variety of applications. High Energy High Intensity Proton Accelerators have great potential applications in nuclear energy sector.

BARC has been working towards the development of heavy ion accelerators, proton accelerators, radioactive ion beam accelerators and electron accelerators. A 5.5 MV Van-de-Graaff accelerator was commissioned in February 1962 and was operational till 1993. This accelerator was upgraded to a 6 MV Folded Tandem Ion Accelerator(FOTIA) and is operating since 2000. This upgraded accelerator utilized the infrastructure such as building, pressure vessel and storage tank from Van-de-Graaff and is capable of accelerating proton as well as heavy ions up to calcium. This accelerator has been operational and has been utilized for various experiments such as Rutherford Backscattering, PIGE, PIXE, Fast neutron induced fission of actinides and minor actinides, radiation biology experiments etc. since year 2000 till date. A 14 MV Pelletron accelerator is also operation since 1988 till date.

Construction of 20 MeV Low Energy High Intensity Proton Accelerator (LEHIPA) was taken up in 2010 in phased manner. This accelerator is in operation since August 2023. A number of experiments, experimental setup for utilization of this accelerator for research purposes are planned. This project has been a milestone on the path towards establishing High Energy High Intensity Proton Accelerators.

Challenges and experience gained during design, construction and operation of FOTIA and LEHIPA will be shared.

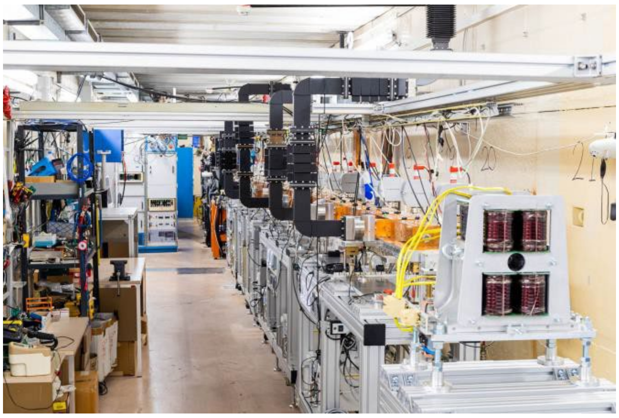
The TOP-IMPLART linear proton accelerator medium accelerator facility

P. Nenzi, G. Bazzano

ENEA C.R. Frascati, Italy

Small and medium-scale accelerator facilities are essential for advancing scientific research, medical applications, and industrial processes. They provide researchers and industries with access to sophisticated technology without the high costs and complexities of large-scale accelerators. The TOP-IMPLART (Intensity Modulated Proton Linear Accelerator for Radiotherapy) exemplifies a medium-scale accelerator facility, demonstrating the use of high-frequency linear accelerators for cancer treatment. This facility, located in ENEA Laboratories at Frascati near Rome, Italy, is a collaborative effort involving ENEA, the Italian Institute of Health (ISS), and the Regina Elena National Cancer Institute (IRE). The TOP-IMPLART project is funded by the Lazio Region through its in-house company Lazio Innova, which is dedicated to innovation, credit, and economic development.

TOP-IMPLART (see Figure 1) is a 71 MeV linear accelerator, with a planned upgrade to 83 MeV within the next two years. It features a commercial 7 MeV injector acquired from the United States company AccSys Technologies, now Hitachi Particle Engineering Services. Following the injector, the accelerator includes two accelerating sections comprised of eight ENEA-patented 3GHz SCDTL (Side Coupled Drift Tube Linac) modules, each section powered by a 10 MW klystron. Additionally, a ninth module is under construction, which will be driven by a third klystron, further boosting the beam energy to 83 MeV.



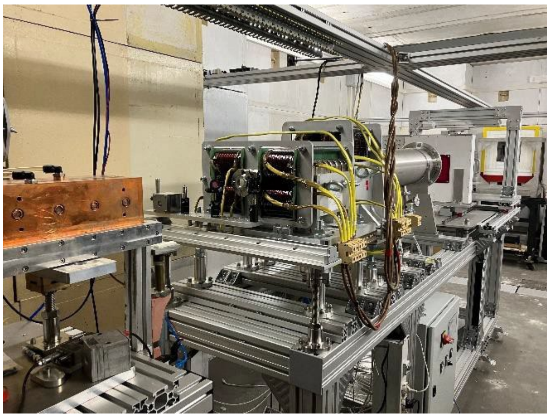


Fig. 1 – TOP-IMPLART accelerator (left), magnetic scanning line and target station (right).

The accelerator generates a pulsed proton beam at a frequency of 25 Hz, with an upgrade planned to reach 100 Hz. The pulse width is adjustable, with a maximum of 100 µs Full Width Half Maximum (FWHM) for the injector beam (up to 7 MeV) and 2.7 µs for the beam accelerated by the 3 GHz modules. The facility includes two irradiation stations: a "low energy" station that delivers the injector beam with energies ranging from 1 MeV to 6 MeV, and a "high energy" station with energies up to 70 MeV. The "low energy" delivery line is oriented vertically, with samples positioned horizontally, enabling the irradiation of biological samples adhered to petri dishes; the “high energy” delivery line is equipped with an XY magnetic scanning system to deflect the beam over a 10 cm by 10 cm area. The samples to be irradiated are placed in an XY remotely operated moving frame that can accommodate samples with edges up to 25 cm. Both stations are equipped with interceptive and non-interceptive diagnostics for beam delivery monitoring and have been thoroughly characterized from a dosimetric perspective.

During its construction, the linac has already demonstrated its versatility as a multidisciplinary irradiation facility. The beam commissioning protocols, essential for validating the efficacy of the proposed linear accelerator technology, have been extended to irradiate samples across various sectors including space, cultural heritage, and life sciences. Specifically, the low-energy line has been utilized for elemental analysis via the PIXE (Proton Induced X-ray Emission) technique on antique samples and is currently undergoing upgrades for the investigation of FLASH effects of protons in the context of FLASH proton therapy studies.

The horizontal high-energy beam line was employed for "in vivo" radiobiology studies to examine the long- term health impacts of proton irradiation on neonatal mice in comparison to photons. In the realm of space technology, the TOP-IMPLART beam is valuable for qualifying electronic components and materials intended for space applications, as well as for conducting experiments related to astrobiology.

The commissioning needs of the linac spurred the development of novel dosimeters that utilize color center formation in Lithium Fluoride Crystals, as well as beam current monitors tailored for lower current levels (such as passive cavity monitors).

The original rationale behind the TOP-IMPLART project was to develop a linear accelerator for proton therapy. This approach was driven by several factors, including reduced space requirements, minimized radiation protection concerns, and the modular nature of the accelerator, which facilitated a quicker Return on Investment. Accelerator modularity allows to deliver therapeutic beams capable of treating tumors during construction enabling, at the same time, the funding of higher energies upgrades. Cost-driven design decisions favored the use of commercial off-the-shelf components and equipment for subsystem realization, provided their performance met the requirements, focusing design efforts to accelerating modules and specific high-power radiofrequency components that were not readily available on the market.

Specifically, technology transfer activities have been conducted with manufacturing companies, specializing them in the production of proton accelerating modules and RF components. This collaboration enabled these companies to supply similar technologies to two related projects in Italy and Europe.

In our experience, justification for small and medium scale accelerator facilities hinges on their multifaceted benefits across various sectors. The development of these facilities fosters regional economic growth. By attracting research institutions, universities, and high-tech companies, regions can become hubs of innovation, creating jobs, and stimulating local economies.

The existence of accelerator facilities frequently fosters collaborations that enrich educational prospects and promote workforce advancement in science and engineering. Small and medium-scale facilities incur lower operational costs compared to larger ones, facilitating their broader dissemination, especially in close proximity to technological districts. This broader reach also ensures the availability of backup options in case a facility experiences a major issue or requires scheduled maintenance.

This is particularly crucial for proton sources, which remain relatively scarce. Linear machines like TOP- IMPLART are particularly well-suited to serve as prototypes for modular proton facilities that can be customized to meet specific demands, thanks to their modular design.

Ensuring interoperability among small and medium-sized facilities, through the establishment of common procedures, intercalibration, and potential alignment with larger ones, is crucial. We will share our experience utilizing the TOP-IMPLART accelerator as a proton irradiation facility across multiple sectors, illustrating how our initial medical-focused project evolved into a versatile facility through experimental activities and industrial collaborations.

Safety and Regulatory Aspects of Small and Medium Scale Accelerator Facilities

Muhammad Ali
Pakistan Institute of Engineering & Applied Sciences, Islamabad, Pakistan

Particle accelerators have proven record of tremendous versatility in their research applications. Since 1939 accelerators have directly contributed to nearly 50 Nobel Prizes. Today small and medium size accelerators are emerging as a research tool in several branches of materials science. Such aaccelerator facilities have diverse applications like scientific research, innovation, industry, education, and training. These facilities not only act as a pivot of infrastructure development but also create an economic impact by stimulating local economies with high-tech jobs and attracting investments which may lead to new innovations. Such important and diverse applications attract regulatory authorities for safe application of radiations ion beams.

In this article we would like to emphasize regulatory aspects for safe operation of the small and medium scale accelerator facilities which are required to be addressed at different stages i.e. planning, operation, waste management and later decommissioning.

Upgrading the SSC facility at iThemba LABS

Sakieldien Moenir
on behalf of the Accelerator operations and Technical Department
iThemba LABS, P.O. Box 722, Somerset West, 7131, South Africa

South Africa has a rich history of building, operating, and developing cyclotrons dating back to the late nineteen forties when the country first embarked on developing expertise in beta and gamma spectroscopy. Since those former years, iThemba Laboratory for Accelerator Based Science (LABS) under the auspices of the National Research Foundation (NRF), has established a significant footprint in various accelerator-based fields such as nuclear physics research, radiotherapy, and production of radioisotopes. As a result of the latter know-how, South Africa is currently at an advance stage with the development of the South African Isotope Facility (SAIF). This facility will largely take over from the existing accelerator infrastructure, the supply of accelerated proton beams for the production of radioisotopes. SAIF will therefore free up the heart of the iThemba LABS facility, the Separated Sector Cyclotron (SSC), to focus on delivering charged particle beams to the nuclear physics community.

The SSC, first commissioned in the mid-nineteen eighties, is a variable energy, multi-particle accelerator capable of achieving single-orbit extraction. This unique capability enables the production of superior beam quality at beam intensities satisfying the varied requirements of various fields of interest to the broader nuclear physics community. The SSC has now been in operation for close to forty years and the effect of the ageing infrastructure is showing on the reliability of the accelerator. To maintain the beam quality and improve on the reliability delivered from this state-of-the-art scientific equipment, iThemba LABS will embark on an extensive programme to restore the capabilities of the accelerator to its former state and beyond. This contribution will present the various interventions that will be embarked on to achieve this objective in the coming months and years.

Applications of high energy ion beams from tandem accelerator for elemental and molecular imaging: micro-PIXE and MeV-SIMS

P. Pelicon[1], M. Kelemen[1], P. Vavpetič[1], B. Jenčič[1], Mirjana Vasić[1], Esther Punzon Quijorna[1], Ž. Barba[1], M. Regvar[2], K. Vogel-Mikuš[1,2] and P. Pongrac[1,2]

[1]Jožef Stefan Institute, Jamova 39, SI-1000, Ljubljana, Slovenia
[2]Biotechnical Faculty, University of Ljubljana, Večna Pot 111, SI-1000 Ljubljana, Slovenia

Due to the numerous advancements in the accelerator technologies, modern tandem ion accelerators are becoming reliable in operation and easy to maintain. They provide excellent conditions for applications in research and technology.

Ljubljana 2 MV Tandetron has been installed in 1997 within the IAEA TCP SLO SLO/1/003. The laboratory has since significantly expanded its research infrastructure in order to support the research in physics, fusion, biology, medicine, energy research, archaeometry and space exploration. As a part of constant instrumentation upgrading, a new 3 MV tandem accelerator has been ordered and expected to be installed in 2025.

Significant share of the available beamtime is dedicated to the chemical microscopies of biological tissue with focused MeV ions using micro-PIXE and MeV-SIMS techniques. The ability to probe elemental and molecular distributions in biological tissue has particular significance for the research in biology, medicine, food science, pharmacology, and forensics. The distribution of elements in the biological tissue can be accessed by a sequence of tissue sectioning, preprocessing and analysis by X-ray emission. In the case of micro-PIXE, tissue slice is irradiated by 3 MeV focused proton beam, and the quantitative elemental distributions of the elements spanning in the periodic table from Na to U are obtained in the form of two- dimensional quantitative elemental maps. Numerous other applications are based on this unique technique, including research in food, proteomics, medicine, pharmacy, and environment.

Imaging mass techniques offer insight into complex biochemical processes by detection of specific biomolecules and their lateral distributions. To be able to determine the localization of large biomolecules in the tissue and cells, it is important to extract significant fractions of non-fragmented molecular ions, as this allows for unambiguous identification of the molecular species. A novel technique of molecular imaging, which is exploiting the impact phenomenon of heavy MeV-ions on the tissue, known as MeV-SIMS, is able to detect the lateral distributions of molecules with masses up to 1500 Da directly in a form of non-fragmented molecular ions.

Research and Management at the Centro Nacional de Aceleradores.

J. Gómez-Camacho, J. García López, C. Guerrero Sánchez, R. García-Tenorio, J.M. López Gutiérrez.
Centro Nacional de Aceleradores, Avda Tomas A Edison, 41092 Sevilla, Spain.

The Centro Nacional de Aceleradores (National Center of Accelerators, CNA) is a joint center of the University of Seville, Junta de Andalucía and CSIC. It is a Unique Scientific-Technical Facility, ICTS, dedicated to interdisciplinary research and therefore open to external users.

To do this, 6 different installations are used: a Van de Graaff 3 MV Tandem accelerator, a 18/9 MeV Cyclotron accelerator, an Accelerator 1 MV Mass Spectrometer, a PET/CT scanner, a radiocarbon dating system called MiCaDaS, and a 60Co Irradiator. The application of these 6 infrastructures covers fields as diverse as materials science, environmental impact, nuclear and particle physics, nuclear instrumentation, medical imaging, biomedical research and preclinical molecular imaging or dating, medical imaging in patients,14C and irradiation in samples of technological and biological interest, among others.

This presentation will describe the trajectory of CNA, from its foundation in 1998. The funding sources, including national and international grants as well as in-site companies, will be explained. Some scientific highlights will be presented. The role of CNA, as well as other small and intermediate accelerator-based facilities, in the european scientific landscape will be discussed.

45 Years of Sustained Operation of the UK National Ion Beam Centre

Roger Webb

UK National Ion Beam Centre, University of Surrey, Guildford, GU2 7XH, UK

The Surrey Ion Beam Centre became a National Facility in 1978 to support academic and industrial research in the application of ion beams to microelectronics. The centre was equipped with a 2MV Van de Graff Accelerator and a 500keV home built ion implanter at that time. The funding associated with the Facility was provided on a 4 year “rolling grant” basis. This meant that every 2 years the facility was reviewed and if successful was awarded an additional 2 years. Full funding was provided for maintenance, staff, travel, consumables and upgrades of the facility and provision of beam time to users was provided free of charge. Additional funding to support new equipment was provided by open completion for research funding. So that an additional high current implanter was built and additional beam lines for the VdG made operational during this period. This format was in place over 16 years. The funding agency was keen to see that its National Facilities were competitive. We instigated a new access model to demonstrate this in which users had to apply for time (tickets) to use the facilities via the funding agency’s grant system. The new model provided 50% of our costs as a “core” research element and 50% through the application for and usage of tickets. This was now reviewed every 2 years. However, the renewal process now occurred at the end of the previous period. This lead to problems that the University did not get sight of the new award before the statutory period in which it has to warn staff of the potential for redundancies. As all staff were tied specifically to the funding this meant that every 2 years staff received redundancy notices every 2 years. Eventually this was fixed by not tying the posts directly to the grant but only to funding which the University would underwrite for a few months while the new contracts were finalised. This was in place for a further 16 years. The funding agency then decided that as we were so successful in attracting time from tickets, we would no longer need the core component and all of our activity from that time on has been funded on the basis of actual use of the accelerators. All users (including ourselves) must have a funded route to access. This has provided us over the years with an increased ability to not just serve the academic community, but also industry and now 50% of our running costs are covered by industrial applications, the other 50% from academia.

Our remit has expanded to support not just microelectronics, but also photonics, solar, nuclear, biological and quantum applications. We have completely renewed our facilities and now run: three implanters (2MV, 1.25MV, and 200keV); two single ion implanters; a 2MV tandem accelerator for ion beam analysis; and we are developing a low energy implanter for isotopic enriched substrates for quantum applications.

To ease our work with industry we applied for and were awarded IS9001 certification in 2007 and have successfully maintained this certification since that time. This has enabled us to maintain the operation of our facilities and to ensure that we keep our user base in mind at all times. Recommendations will be given as part of this presentation on how best to provide continuous and sustained operation of such a facility.

Status and development of electrostatic accelerator-based facilities at the Institute of Applied Physics of National Academy of Sciences of Ukraine

V.A. Baturin, O.M. Buhay, A.A. Drozdenko, A.G. Ponomarev, V.E. Storizhko
Institute of Applied Physics of National Academy of Sciences of Ukraine, Sumy, Ukraine

The Institute of Applied Physics (IAP) of the National Academy of Sciences (NAS) of Ukraine was organized in the second half of the 80s of the last century. The main objective of the institute was to develop analytical complexes based on electrostatic accelerators and microanalysis techniques using nuclear physics methods. The choice of the location of the institute was because the SELMI electron microscope plant was located in the city of Sumy, where it was planned to mass-produce such analytical complexes. With the collapse of the Soviet Union, in the first years, the IAP underwent formation and development in the new state of Ukraine, which were associated with certain difficulties. Subsequently, the IAP became part of the Division of Nuclear Physics and Energy of the NAS of Ukraine, which should accompany the operation and development of nuclear power plants located in Ukraine. The main objectives of the institute were formulated: study of the processes of interaction of ions, electrons and photons with matter, including biological objects and fields; development of nuclear physics methods for studying the structure and composition of materials and electrostatic accelerators.

The beginning of the creation of the Analytical Accelerator Complex (AAC) in the IAP was associated with the commissioning of a compact electrostatic accelerator of the Van de Graaff type with a maximum voltage at the high-voltage terminal of 2 MV. Such an accelerator was supplied by the Kharkiv Institute of Physics and Technology with the financial support of the project of the Science and Technology Center of Ukraine (STCU). Subsequently, IAEA projects, as well as partner and regular STCU projects, with funding from the United States of America and the European Union to a certain extent helped to create the analytical channels of the complex. The main financial investments in the AAC were and continue to be received at the expense of the state program of Ukraine "Nuclear Materials and Radiation Technologies", as well as other projects financed by the NAS of Ukraine. It is also worth noting the assistance in the form of equipment supplied by the Institute of Nuclear Physics, University of Munster, Munster, Germany and the Institute of Theoretical and Applied Physics, University of Stuttgart, Stuttgart, Germany.

Main parameters of the accelerator: ion type H^+, H_2^+ He^+, He^{++}; accelerating voltage, 0.3…2.0 MV; energy homogeneity of a beam, 0.08%; proton beam current, up to 50 μA; operating mode - continuous; mass 3000 kg. The accelerator was modified during its operation. In particular, a radio-frequency ion source was equipped with a system of permanent magnets to enhance plasma density. A charging system of high-voltage terminal was upgraded to diminish instability of high voltage. A system of X-ray suppression of an accelerator was also developed and constructed. Nd-Fe-B permanent magnets installed along an accelerating tube decrease a radiation dose by two orders of magnitude. Currently, AAC includes four analytical channels.

The scanning nuclear microprobe channel is located at an angle of 0^o after the switching magnet. Main application: local elemental micro-analysis of various materials. Parameters of the microprobe: ion type H+, He+; energy 1.0…1.8 MeV; current on a target 10…1000 pA; spatial resolution (at current on a target of 200 pA) about 2 µm; scanning raster 1×1 mm^2; analytical techniques PIXE, RBS, ERDA, SEE. The main studies that were carried out on the channel. Study of impurity migration at the interface of stainless steel and zirconium alloys in fuel assemblies under cyclic thermal loading. Determination of the distribution of chemical elements in geological samples of uraninites from different deposits (Ukraine, Afghanistan and Egypt) for nuclear forensics. The use of a microprobe was due to the micrometric dimensions of the samples, which does not require the use of a hot chamber and the exceptional sensitivity of the method for recording characteristic X-ray radiation induced by a focused proton beam. The proton beam writing channel is a continuation of the microprobe channel. Main application: manufacture of X-ray diffraction gratings.

Channel at an angle of 30^o is equipped a magnetic spectrometer with relative energy resolution $\Delta E/E<3.2\times10^{-3}$, which gives 3.2 keV energy resolution, when 1 MeV projectiles are used for RBS analysis. It allows studying films with thickness from several nanometers to several microns. Application: study of a structure and composition of film coatings of various materials. Specifications: ion type H+, He+; energy 1.0…1.8 MeV; energy resolution $\Delta E/E=3.2\times10^{-3}$; analytical technique RBS. The target chamber of the channel also contains an X-ray detector, which allows the implementation of the macro-PIXE method. Research is carried out here to determine the artifacts of historical heritage.

Channel at an angle of 45^o is for elastic recoil detection analysis. Application: non-destructive quantitative analysis of hydrogen concentration in materials. This channel may also be applied for RBS technique both at reverse and sliding angles. Specifications: ion type He+, H+; energy 1.0…1.8 MeV; current on a target from 10 to 1000 nA; energy resolution $\Delta E/E=1.5\times10^{-3}$ (at beam energy of He+ =1000 keV), 1.5 keV; analytical techniques – ERDA, RBS; detection limits of hydrogen 1…10 ppm.

Channel at an angle of -30^o is for the generation of quasi-monochromatic X-rays with an electrostatic accelerator. The use of a converter, which is bombarded by an ion beam of MeV-energies as an X-ray source, permits generation of an X-ray beam with parameters required for conducting research based on the method of linear and differential phase contrast. The channel is under development. The intended application is in phase-contrast tomographs for medicine and material structure research.

Development of the ATLAS accelerator facility at Argonne

Guy Savard

Physics Division, Argonne National Laboratory, USA

The ATLAS facility at Argonne National Laboratory is a DOE Nuclear Physics national user facility serving the US and international nuclear physics community. It provides its users with beams from any stable species from proton to uranium at energy up to 10-20 MeV/u and a full suite of state-of-the-art experimental equipment for nuclear structure and nuclear astrophysics studies at that energy regime. Upgrades to the facility over the last decade have added capabilities to accelerate short-lived neutron-rich radioactive isotopes from fission using the CARIBU upgrade and light short-lived radioactive beams with the RAISOR separator.

The capabilities of the facility, and how they build on each other to optime scientific output, will be described. The planning process that guided these developments, and which involved significant user community input, will also be presented.

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