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Technical Meeting on Novel Applications of Accelerator-based Techniques for Socio-economic Benefits

IAEA Headquarters, Vienna, Austria, 11 – 13 December 2023

EVT2205716

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 11 – 13 December 2023.

The abstracts are listed in alphabetic order of the name of the IAEA Member States represented in the Meeting

Prepared by

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

Technical Meeting on Novel Applications of Accelerator-based Techniques for Socio-economic Benefits

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(EVT2205716)

MEETING AGENDA

Monday, December 11, 2023 - Morning Sessions -		
Time (CET)	**Topic of presentation / discussion**	**Speaker and affiliation**
09:30 – 09:50	*Opening – welcome addresses*	**Ms Melissa Denecke,** *Director, NAPC, IAEA* **Mr Danas Ridikas,** *Section Head, Physics Section, NAPC,*
09:50 – 10:00	*Objectives and expected outputs of the Technical Meeting*	**Mr Sotirios Charisopoulos,** *Physics Section, NAPC, IAEA*
10:00 – 10:20	*Accelerating Solutions for Society; Synergies of Discovery Science and Applications at the Texas A&M Cyclotron Institute*	**Ms Sherry J. Yennello** *Texas A&M University, College Station, TX 77843, USA*
10:20 – 10:40	*Societal impact of Synchrotron radiation: the case of Elettra-Sincrotrone Trieste*	**Ms Giuliana Aquilanti** *Elettra – Sincrotrone Trieste, Trieste, Italy*
10:40 – 11:00	*TRIUMF Accelerator Applications for the Benefit of Canada and the World*	**Mr Alexander Gottberg** *TRIUMF, Vancouver, Canada*
11:00 – 11:30	*Coffee / Tea break*	
11:30 – 11:50	*Accelerating Progress: Malaysia's Strategic Approach to Accelerators and Nuclear Science*	**Ms Siti Najila Mohd Janib,** *Malaysian Nuclear Agency, Selangor, Malaysia*
11:50 – 12:10	*Development and Application of Accelerators at CIAE*	**Mr Yuntao Liu,** *China Institute of Atomic Energy, Beijing, China*
12:10 – 12:30	*Status and Beam Utilization of a Proton Linac at KOMAC*	**Ms Seunghyun Lee,** *Korea Multipurpose Accelerator Complex, KAERI, Gyeongju 38180, Korea*
12:30 – 14:10	*Lunch break*	

Monday, December 11, 2023 - Afternoon Sessions -		
Time (CET)	**Topic of presentation / discussion**	**Speaker and affiliation**
14:10 – 14:30	*Science Opportunities at SESAME*	**Mr Andrea Lausi** *SESAME, Allan, Jordan*
14:30 – 14:50	*4th Generation High Energy Synchrotron X-rays: A Pivotal Large-Scale Tool with Socio-Economic Benefits*	**Ms Marta Mirolo** *The European Synchrotron (ESRF), Grenoble, France*
14:50 – 15:10	*ESS: from protons to neutrons, the accelerator science improving daily-life.*	**Mr Marcelo Juni Ferreira,** *European Spallation Source ERIC, Lund, Sweden*
15:10 – 15:30	*Research at the Portuguese Ion Beam Laboratory*	**Ms Katharina Lorenz** *Instituto Superior Técnico, Univ. of Lisbon, Bobadela, Portugal.*
15:30 – 16:00	*Coffee / Tea break*	
16:00 – 16:20	*Recent and novel applications of the TANDEM accelerator at the Bariloche Atomic Centre.*	**Mr. Raul O. Barrachina** *National Atomic Energy Commission, Argentina.*
16:20 – 16:40	*Elemental analysis of edible plants with accelerated ion beams*	**Mr Primoz. Vavpetič,** *Jožef Stefan Institute, Ljubljana, Slovenia.*
16:40 – 17:00	*The ATOMKI Accelerator Centre serving science, technology, and innovation.*	**Mr Zsolt Fülöp** *ATOMKI, Debrecen, Hungary*

Tuesday, December 12, 2023 - Morning Sessions -		
Time (CET)	**Topic of presentation / discussion**	**Speaker and affiliation**
09:30 – 09:50	*The Italian Centre for Oncological Hadrontherapy (CNAO): societal impact and sustainability*	**Mr Sandro Rossi** *Fondazione CNAO, Pavia, Italy*
09:50 – 10:00	*Medical applications with heavy/radioactive ion beams at accelerator institutes*	**Ms Charlot Vandevoorde** *GSI Helmholtz Center for Heavy Ion Research, Darmstadt, Germany*
10:00 – 10:20	*BNCT activities in Japan and worldwide and their link to socio-economic impact*	**Ms Kazuyo Igawa** *Neutron Therapy Research Center, Okayama University, Japan*
10:20 – 10:40	*The Radiological Research Accelerator Facility at Columbia University*	**Mr Guy Garty** *RARAF, Nevis Laboratory, Columbia University, Irvington, NY 10533, USA*
10:40 – 11:00	*Enhancing Medical Diagnostics in Endoprosthesis Failure Cases with Particle Induced X-ray Emission (PIXE)*	**Ms Esther Punzón-Quijorna** *Jožef Stefan Institute, Ljubljana, Slovenia.*
11:00 – 11:30	*Coffee / Tea break*	
11:30 – 11:50	*Applications and Commercial Activities at JYFL-ACCLAB*	**Mr Paul Greenlees** *Accelerator Laboratory, Dept. of Physics, University of Jyväskylä, Finland*
11:50 – 12:10	*Case Study Methods for Estimating the Socio-Economic Benefits of Accelerator-Based Techniques*	**Ms Amanda Walsh** *RTI, International, RTP, NC 27709 USA*
12:10 – 12:30	*Access to Accelerator Mass Spectrometry @ VERAcore for Applications for Socio-economic Benefits: From Be-10 to Actinides*	**Ms Silke Merchel** *University of Vienna, Faculty of Physics, Isotope Physics, Vienna, Austria*
12:30 – 14:10	*Lunch break*	

Tuesday, December 12, 2023 - Afternoon Sessions -		
Time (CET)	**Topic of presentation / discussion**	**Speaker and affiliation**
14:10 – 14:30	*Development of novel fields of electron beam accelerators applications – INCT perspective*	**Ms Urszula Gryczka** *Inst. of Nuclear Chemistry and Technology, Warsaw, Poland*
14:30 – 14:50	*Establishing a mobile unit with an electron beam accelerator to treat industrial effluents for reuse purposes in Brazil.*	**Mr Wilson Aparecido Parejo Calvo** *Brazilian National Nuclear Energy Commission, Rio de Janeiro, Brazil*
14:50 – 15:10	*Development of electron linear accelerators for societal applications*	**Ms Shreya G Sarkar,** *Bhabha Atomic Research Centre, Mumbai, India*
15:10 – 15:30	*E-beam Developed Polymeric matrices for Biomedical Applications: An Integrated platform Toward Socio-Economic Growth and Value Creation*	**Ms Amany Ismael Mahmoud Raafat** *National Center for Radiation Research and Technology, Egyptian Atomic Energy Authority, Cairo, Egypt*
15:30 – 16:00	*Coffee / Tea break*	
16:00 – 16:20	*30 years of ion beam analysis at LAMFI-USP: past experiences and insights for the future*	**Mr Manfredo Harri Tabacniks** *Inst. of Physics, Univ. of São Paulo, Brazil*
16:20 – 16:40	*An irradiation platform to promote and disseminate the benefits of using electron accelerators.*	**Mr Florent Kuntz** *Aerial - Innovation Park - 250 Rue Laurent Fries, 67400 Illkirch, France*
16:40 – 17:00	*Research facilities and highlights at the Centro Nacional de Aceleradores (CNA)*	**Mr Javier Ferrer** *CNA Centro Nacional de Aceleradores. Sevilla, Spain*

Wednesday, December 13, 2023 - Morning Sessions -		
Time (CET)	**Topic of presentation / discussion**	**Speaker and affiliation**
09:30 – 09:50	*IAEA activities in support of sustainable development of accelerator facilities and the IAEA Ion-Beam Facility Project*	**Mr Sotirios Charisopoulos,** *Physics Section, NAPC, IAEA*
09:50 – 10:10	*IAEA activities in support of accelerator-based applications of industrial interest.*	Speaker to be confirmed. *RCRT Section, NAPC, IAEA*
10:10 – 11:00	*Round table discussion*	**All participants**
11:00 – 11:30	*Coffee / Tea break*	
11:30 – 12:30	*Preparation of the draft meeting report*	**All participants**
12:30 – 14:00	*Lunch break*	
14:00 – 15:00	*Finalizing the meeting report and recommendations to the IAEA*	**All participants**
15:00	*End of the Technical Meeting*	

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Recent and novel applications of the TANDEM accelerator at the Bariloche Atomic Centre.

R. O. Barrachina[1]

[1]*National Atomic Energy Commission, Argentina.*

Since its creation in 1960 by Prof. Wolfgang Meckbach, our “Department of Interaction of Radiation with Matter” (DIRM) is dedicated to Research and Development based on Ion Beam Accelerators. It is located at the Bariloche Atomic Center and depends on the National Atomic Energy Commission. One of its main facilities is a 1.7 MV Tandem accelerator with PIXE, RBS, ERDA, NRA and channeling capabilities, and a chamber for Cold Target Recoil Ion Momentum Spectroscopy (COLTRIMS). One of its beam lines is dedicated to material analysis and ion implantation, with micro-beam capability, and a NEC RC43 chamber. At present, a WDS facility is being incorporated. This equipment is routinely employed for the compositional and structural characterization of samples. During this presentation we will describe some of the applications in fields as diverse as mineralogy, biology, medicine, environmental science, and archeology. We will also show the first results of a novel technique for the measurement of Ion-impact X- ray Emission based on High-pressure Gas Ampoules in Silicon Blisters.

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Access to Accelerator Mass Spectrometry @ VERAcore for Applications for Socio-economic Benefits: From Be-10 to Actinides

S. Merchel, K. Hain, M. Martschini, P. Steier, R. Golser
University of Vienna, Faculty of Physics, Isotope Physics, Vienna, Austria

Anthropogenic and cosmogenic long-lived radionuclides–from ^{10}Be to actinides–can be determined at ultra-low level (10^{-15}) via accelerator mass spectrometry (AMS) at "VERAcore", Vienna, Austria.

For more than 25 years the Isotope Physics group operates the Vienna Environmental Research Accelerator (VERA) based on a 3 MV tandem accelerator (Fig. 1) [1,2]. Since then, VERA offered access to a large number of external users for basic and applied research, e.g., via Horizon 2020- and Horizon-Europe-funded projects. To allow users from academia and industry an easy, flexible, transparent and efficient access to VERA a so-called Core Facility has been established in January 2023: "VERAcore" [3].

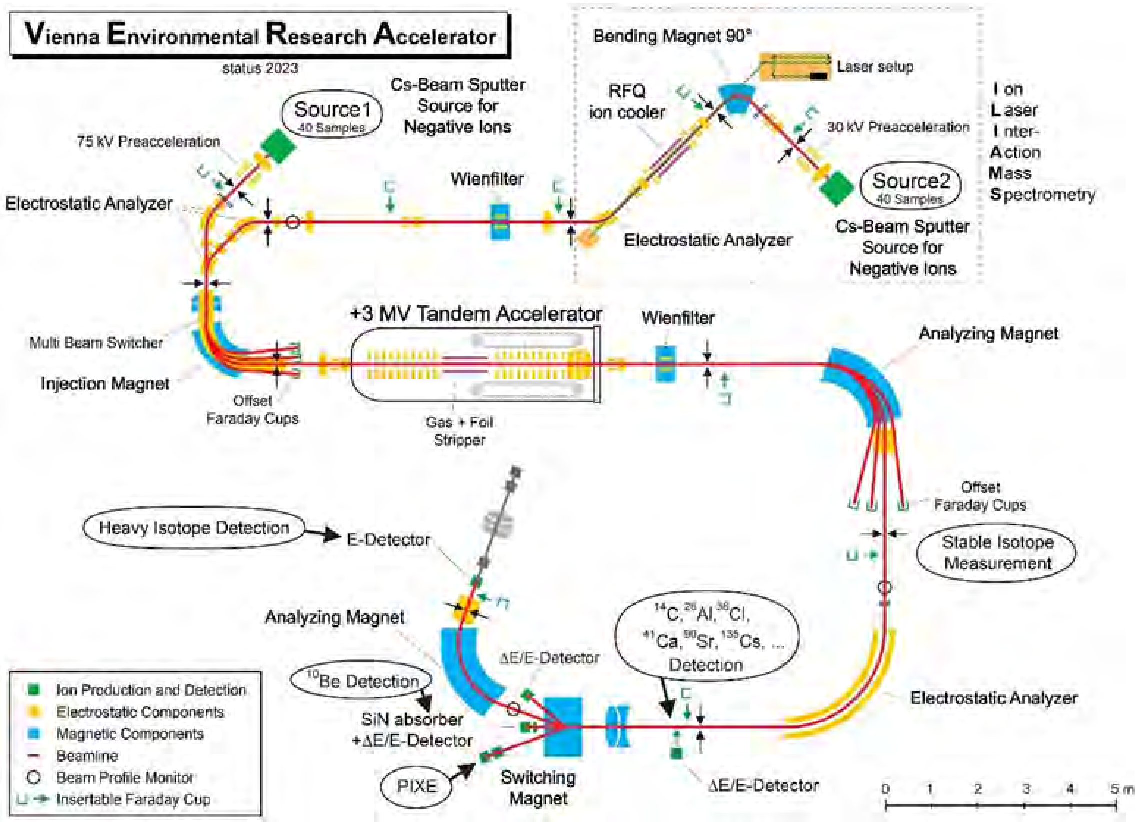

Figure 1. Overview of the VERA facility. More detailed version at [2].

VERA is one of the first accelerators dedicated and designed AMS all across the nuclear chart and has been continuously extended ever since. VERA can measure all standard AMS radionuclides like the long-lived ^{10}Be, ^{14}C, ^{26}Al, ^{36}Cl, ^{41}Ca and ^{129}I (Fig. 2) and is especially well-suited for the determination of ultra-low level actinides (U, Np, Pu, Am). AMS measurements on the complete set of established nuclides are performed for (i.e., hands-off) and in cooperation with partners (i.e., hand-on).

VERA is also well-known for hosting international guests for education and training of both, AMS sample preparation and running an AMS facility, often yielding into performing common AMS measurements. VERAcore is following this avenue, too.

Mostly only AMS reaches the selectivity and sensitivity to single out the small number of radionuclides at natural levels where abundance sensitivities are of typically 10^{-15} and lower. Recent and on-going technical developments at VERA such as the world-wide unique Ion- Laser Interaction Mass Spectrometry (ILIAMS) system [4] expand(ed) the scope of AMS significantly. Especially the new access to ^{90}Sr [5], ^{135}Cs [6], ^{99}Tc, $^{233/236}$U, and ^{237}Np [7], and improved measurement scheme for the radiohalogenides ^{36}Cl and ^{129}I will increase applications relevant to socio-economic benefits such as oceanography, hydrology, glaciology, climate research, and nuclear waste characterization. For example, our latest project [ReMade@ARI](https://remade-project.eu/) (REcyclable MAterials DEvelopment at Analytical Research Infrastructures) [8] offers free access for materials characterization to make a substantial impact on the circular economy.

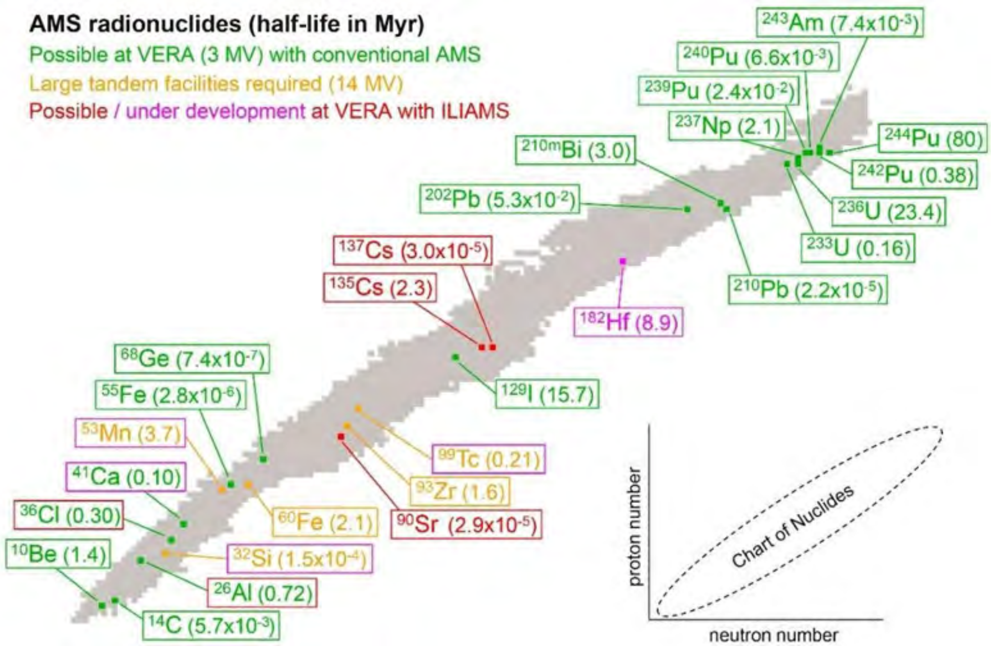

Figure 2: Long-lived radionuclides measurable by AMS at VERA and other large tandem facilities [3].

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Establishing a mobile unit with an electron beam accelerator to treat industrial effluents for reuse purposes in Brazil.

W.A.P. Calvo[1], S.L. Somessari[1], A. Feher[1], M.C. Sa[1], F.F. Lainetti[1], R.R. Gaspar[1], T.M. Silva[1], R. Blatt[2], A. Braga[2], M. Rodrigues[2], M.H.O Sampa[1],

[1]*Nuclear and Energy Research Institute (IPEN-CNEN),*

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Radiation technology has been used to control environmental pollution. The treatment of wastewater and industrial effluents by electron beam irradiation is a promising technique. The design and construction of a mobile unit by the Nuclear and Energy Research Institute (IPEN- CNEN) together Truckvan Industry, containing an electron beam accelerator of 0.7 MeV, 20 kW and 640 mm window is innovative to demonstrate the effects and positive results of this technology, as shown in Figure 1. The resources for the development of the unit have been supplied by the Brazilian Innovation Agency (FINEP) and the International Atomic Energy Agency (IAEA). A 3D model study of the control room and laboratory space was done to facilitate understanding the internal distribution of the laboratory analysis equipment (Gas Chromatography Mass Spectrometry, Total Organic Carbon and UV-Visible Spectroscopy), as shown in Figure 2.

The mobile unit with electron beam accelerator will treat industrial effluents at different locations in combination with other techniques. The main technical aspects of this treatment capacity are the following: a) Mobile Electron Accelerator of 20kW can treat up to 1,000m^3/day of drinking water with 1kGy dose; b) 500m^3/day of textile dyeing wastewater with 2kGy dose; c) 340m^3/day of raw sewage, secondary and chlorinated effluents with 3kGy dose; d) 50m^3/day of organic compounds (benzene, toluene, ethyl benzene, xylenes and phenol) from petroleum production water with a dose of 20kGy; and e) 20m^3/day of polychlorinated biphenyl (PCB) with a dose of 50kGy. Treatment costs with Mobile Electron Beam Accelerator of typical drinking water and wastewater are presented in the Business Plan, which is associated with the project sustainability. To enlarge the national capacity to treat industrial effluents using electron beam accelerators, the mobile unit treating effluents on site from 1m^3/h up to 1,000m^3/day, will provide an effective facility between a laboratory-scale plant to a large-scale plant with the objective to demonstrate the efficacy and transfer the technology. Many studies in the country and in other foreign laboratories have already proved that radiation treatment offers technological and economic benefits over the conventional techniques for treating recalcitrant pollutants.

FIG. 1 - Mobile electron beam irradiation unit for the treatment of industrial effluents in Brazil.

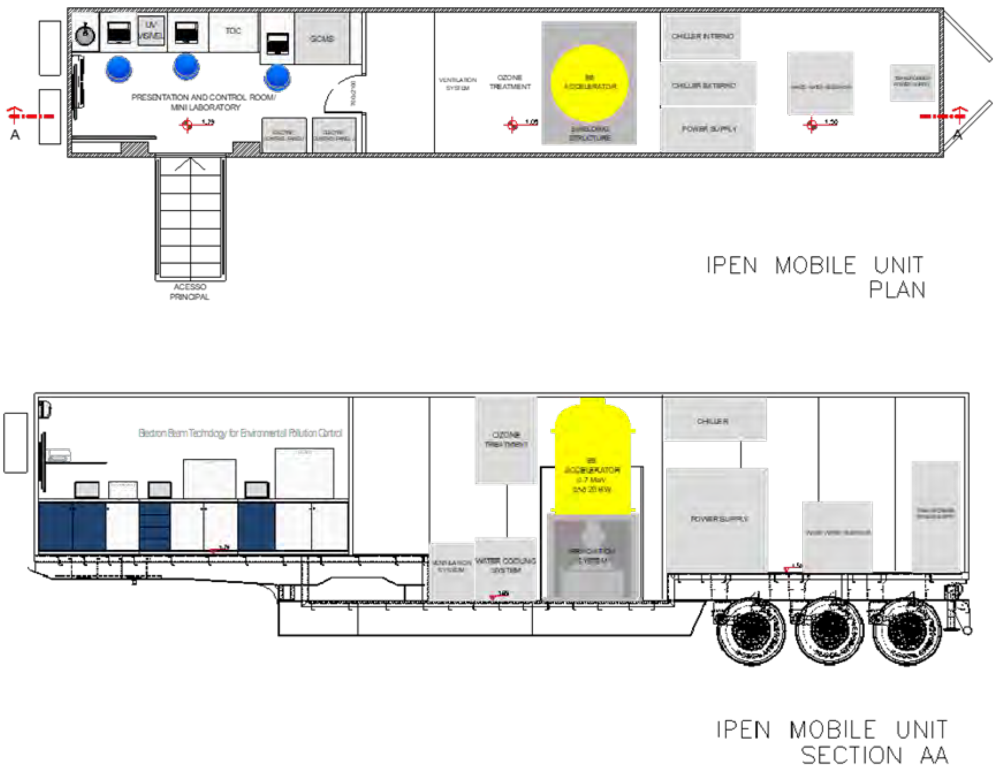

FIG. 2 - Architectural drawings of the IPEN-CNEN mobile unit (a) Plan and (b) section AA (15m length, 2.6m width and 4.4m height).

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30 years of ion beam analysis at LAMFI-USP: past experiences and insights for the future

Manfredo Harri Tabacniks and Tiago Fiorini da Silva

Institute of Physics, University of São Paulo, Brazil

1. Introduction

The socioeconomic impact of science in modern societies helps shape the economic and social well-being of people. Science education empowers individuals in a knowledge-based society favoring innovation and entrepreneurship. It drives progress and reduces inequalities across populations. Socioeconomic impacts of science may vary across different regions and countries. In emerging countries like Brazil, the impact of science is primarily seen in the preparation of qualified human resources, which is arguably its most valuable outcome.

PIXE analysis using small accelerators began widespread use in 1970 for air pollution research, later extending to the analysis of archaeological or artistic objects. The goal is to correlate measured elements with the environment or their origins. Small accelerators play a crucial role in testing microcircuits' tolerance to radiation, impacting high-tech fields such as avionics, the space industry, and autonomous cars. IBA proves invaluable for quality control and diagnostics of high-tech materials, assuming a well-developed industry capable of demanding and paying for the analysis.

In the specific case of IBA, LAMFI-USP (acronym for the Laboratory of Material Analysis with Ion Beams at the University of São Paulo) has been providing high-standard material analysis to Brazilian scientists for over 30 years.

2. The socioeconomic impact of an IBA facility in Brazil

In the field of Environmental science, PIXE technology was introduced at the University of São Paulo in 1975 to support research on air pollution based on the elemental analysis of atmospheric aerosols [1], by selecting eight sites around Brazil for aerosol sampling and PIXE analysis [2]. In the first decade of LAMFI-USP, measured trace elements in tree rings of a (166±16) years-old tree from the Amazon Basin [3]. PIXE detected trace elements were associated with worldwide modifications in the environment during the life of the tree. e.g., the eruption of the Krakatoa volcano in 1883 or a period of great drought and biomass burning in the Amazon from 1911 to 1926, revealing the potential of paleoclimate research measuring trace elements.

In the field of Health science, a multielement Analysis of Genetically Modified Food using INAA and PIXE Techniques [4] was conducted on natural soybean seeds. The results revealed higher concentration values for Br, Ca, Cl, Cr, Mn, K, P, S, and Zn in genetically modified soybeans cultivated in Brazil. Similarly, trace element measurements in teeth collected from preterm and full-term babies pointed to higher amounts of Ca, P, Cu, and Zn in the enamel, as well as a significantly higher amount of strontium in the whole teeth of premature babies. These findings open new avenues for studying enamel mineralization in primary dentitions [6].

In the field of archaeology, X-ray radiography and PIXE analysis were employed to characterize 36 pre-Hispanic ceramic pieces from the Chimu Culture conserved in the Museu de Arqueologia e Etnologia (MAE/USP). The measurements aided in identifying the manufacturing processes of the ceramics, contributing to the classification of different cultures that inhabited the site [7].

In the field of material science, the existing experimental infrastructure at IFUSP, comprising two small tandem ion accelerators with 1.7MV and 8MV, was used to test and qualify integrated circuits for operation in ionizing radiation environments [8]. This has strategic importance and significant economic impact, even in developing countries. LAMFI also plays a crucial role in national research on solar cells, providing high-quality thin-film analysis [9]. The new generation of nuclear fusion reactors necessitates massive sample analysis of its internal walls, requiring small accelerators used for IBA and innovative data analysis methods to aid development.

In terms of teaching and outreach, while teaching undergraduates modern physics, the Cockcroft-Walton experiment, measuring the 7Li(p,α)4He reaction, was reproduced at LAMFI-USP using a regular RBS setup. Due to its high Q value, this reaction serves to demonstrate mass-energy equivalence and introduce the Gamow tunneling theory. Small particle accelerators offer a unique opportunity for students to experience the daily work of a scientist in situ. For high school students, visiting such a facility can spark scientific curiosity and interest in a science career.

LAMFI's external beam setup [10] is a national technological example, locally built and installed in 2018. The setup, which combines a submillimeter beam with a large computer-controlled XYZ robotic stage, with a span range of (60.0000±0.0005) cm in each axis, is the flagship of LAMFI-USP for PIXE analysis of various materials, including fossils, wood samples, sediments, stalactites, ceramics, and paintings. High-precision computer vision is used to focus and compensate for irregularities of the sample's surface, reducing analytical artifacts.

3. Discussion and conclusions

The research activities at LAMFI-USP are highly interdisciplinary, contributing to environmental science, archaeology, the development of solar cells, and the testing of circuits in ionizing environments. The impact extends to science education, outreach, and the qualification of human resources.

Applied science produces an additional benefit by generating scientific problems that motivate basic science investigations. This helps develop science in general and, in our case, IBA and its technology.

Looking ahead, the increasing need for better results will drive improvements in analytical setups, the development of better detectors, time-resolved analysis, and the creation of new instrumentation for complementary measurements. There is a growing need for more data on radiation effects in solid materials and on stopping powers near the Bragg peak. Additionally, the analysis of trace elements focusing on microplastics and flame retardants in biological systems is a recent trend to be explored.

Facilitating access to IBA facilities for students and researchers promotes a more inclusive scientific community and greater diversity in solutions to important scientific questions.

4. References

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TRIUMF Accelerator Applications for the Benefit of Canada and the World

Alexander Gottberg

TRIUMF, Vancouver, Canada

For 50 years, TRIUMF has stood at the frontier of scientific understanding as Canada's Particle Accelerator Centre. Driven by two made-in-Canada cutting edge accelerators - the world's largest cyclotron, and our new high-power superconducting linear accelerator - we continue to ask the big questions about the origins of the universe and everything in it.

With over five decades of experience in the production of accelerator-based secondary particles for science, TRIUMF also ensures that Canada remains on the leading edge of supplying radioisotopes, neutrons, photons, and muons enabling fundamental science in the fields of nuclear, particle and astrophysics, as well as solid state and medical applications, cancer research, electronics radiation testing and particle detector development.

ISAC-TRIUMF is the only ISOL facility worldwide that is routinely producing radioisotope beams in the high-power regime in excess of 10 kW. TRIUMF's current flagship project ARIEL, Advanced Rare IsotopE Laboratory, will add two new target stations providing isotope beams to the existing experimental stations in ISAC I and ISAC II at keV and MeV energies, respectively. This will put TRIUMF in the capability of delivering three RIBs to different experiments, while producing radioisotopes for medical applications simultaneously – enhancing the scientific and socio-economic output of the laboratory significantly.

Together with commercial and public partners, TRIUMF generates 2M+ patient doses of medical radioisotopes per year to contribute to diagnostics and treatments of patients in Canada and worldwide. Driven by a set of in-house designed cyclotrons, delivering from 13 MeV to 500 MeV protons, a great variety of medically relevant isotopes from C-11 to Ac-225 are produced for R&D and application. Direct radiation therapy applications are developed using both, the 50-500 MeV cyclotron, as well as a 10-30 MeV electron linac. Both systems can produce ultra-high dose rate radiation pulses for Flash radiotherapy studies.

Radiation damage studies are performed in a range of radiation fields. Material displacement damage is characterized in materials for nuclear fission (SMR, ADS), fusion and accelerator applications in high dose environments. Low-dose neutron fields are used or made available to industry to study radiation effects in electronics.

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Development and Application of Accelerators at CIAE

Yuntao Liu, Shizhong An, Zhibin Zhu

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China Institute of Atomic Energy (CIAE) has been devoted to the development of the technologies on proton cyclotrons and electronic linacs in the field of national economy and the people's livelihood since 1958, when the first cyclotron had been built at CIAE. A series of proton cyclotrons with the energy ranges of 10MeV-250 MeV have been developed successfully for different applications. The first radioactive isotope production cyclotron in China, CYCIAE-30, was built in 1995, which is still in operation to provide radioactive isotope. Many kinds of medical radioactive isotopes were produced and used in the hospital, such as 18F, 64Cu, 123I, 99Tc, etc. As the core equipment of Beijing Radioactive Ion-beam Facility (BRIF), CYCIAE-100, was built in 2014 and the isotope production experiments of 225Ac was finished with this machine. The high current compact cyclotron, CYCIAE-14, was successfully built and the beam current was reached 1mA in 2021. The first Boron Neutron Capture Treatment (BNCT) device based on 14MeV/1mA cyclotron was developed successfully and the epithermal neutron flux density was up to 1.0×10^9/cm^2/s for the cancer treatment. The BNCT cancer treatment center is building in China with 18MeV/1mA cyclotron. The 230MeV superconducting cyclotron for proton beam therapy is building and the proton therapy device will be put in the hospital next year. Based on the advanced accelerator technology, CIAE also develops the neutron imaging equipment based on compact cyclotron neutron source, Movable neutron/gamma source, ion implanter, etc.

China's first 10MeV/15kW electron irradiation accelerator

China's first self-shielding electron beam sterilization accelerator

China's first S band NDT electron linear accelerator

China's first C band NDT electron linear accelerator

China's first L band electron linear accelerator

The first X band electron linear accelerator for customs container inspections

China's first electron linear irradiation accelerator

China's first 6MeV electron linear accelerator for customs inspections

Medical cyclotron

As an artificial ray source, electron linear accelerator is not only widely used in basic scientific research, but also in industry, agriculture, medical and environmental protection industries. The first electron linear accelerator for non-destructive testing was successfully developed in China in the 1990s, and then a series of products such as 2MeV, 4MeV, 6MeV, 9MeV and 12MeV were gradually formed. At present, the power of the accelerator has reached 24.3kW, and can run stably, sold to many domestic enterprises, mainly used for garlic, tea preservation and pet food, pepper powder disinfection and sterilization. They are mainly used in the petrochemical industry, air separation industry thick wall pressure vessel welding seam, thermal power and nuclear power plant pipeline, boiler, valve welding seam, slag, high-speed train key components, engine defects detection. China's national standard for electron linear accelerators for nondestructive testing is formulated by China Atomic Energy Institute. Two international standards based on electron linac and cyclotrons used of PET were led by CIAE and were successfully released, which has become the benchmark of international standards in the field of general nuclear instruments in China and accumulated experience for the formulation of international standards of CNNC.

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E-beam Developed Polymeric matrices for Biomedical Applications: An Integrated platform Toward Socio-Economic Growth and Value Creation

Amany Ismael Mahmoud Raafat

Polymer Chemistry Department, National Center for Radiation Research and Technology
Egyptian Atomic Energy Authority

Increasing traumatic injuries, severe hemorrhagic wounds, and bone diseases resulted in an increasing need for biomaterials that can stimulate tissue regeneration and healing. The development of unique biomaterials based on natural polymers has been facilitated through the use of electron beam irradiation technology as a clean source of initiation and crosslinking accomplished by sterilization to promote human well-being and healthy living. An important part of the design and development of biomedical products is the selection of appropriate biomaterials and equally important is the suitability of the preparation technique to meet the characteristics required for the proposed application or to expand the range of products for marketing.

Electron beam irradiation-assisted technology is an excellent way to fabricate biomedical materials compared to other synthesis methods. It is a fast, eco-friendly, additive-free process that involves both synthesis and sterilization of materials in one technological step: thus reducing the cost and production time of the process.

In biomedical applications, polymeric biomaterials should be capable of performing their dedicated functions in a range of physiological conditions, including temperature, pH, osmotic pressure, and ionic strength.

Hydrogels are water-swollen hydrophilic crosslinked polymeric networks that imitate the structural, biomechanical, and biochemical functionalities of the extracellular matrix and have immanent bioactivity and biocompatibility, forming marvelous candidates for the development of matrices for biomedical applications.

Hydrogel-based dressings, provide promising materials with new properties and treatment options that can emerge as prime candidates for wound management and tissue repair. While hemostatic hydrogel dressings are used locally to prevent hemorrhage-related deaths, manage extensive blood loss, reduce blood transfusion requirements, decrease infection risk, and reduce the need for blood transfusions. Military and civilian emergency medical sites use these dressings to stop bleeding after traumatic injuries and after surgical wounds. In addition, hydrogel hybrid systems "biocomposites" containing hydroxyapatite (HAp) can be designed as scaffolds mimicking the natural matrix of the bone where the inorganic apatite nanocrystals are aligned on a three-dimensional architecture along the woven collagen fibers.

Herein, the electron beam irradiation-assisted preparation as well as the appropriate characterization of the mentioned types of biopolymers-based hydrogels will be reviewed. A variety of natural polymers, including Acacia, Xanthan, Tragacanth, Hydroxyethylcellulose, Hydroxypropyl-methylcellulose, and Gelatin, were modified by crosslinking or by grafting- induced copolymerization with different synthetic polymers, such as polyvinylpyrrolidone, polyvinyl alcohol, and carpabol, to improve their mechanical properties. These developed hydrogel matrices have been enhanced with biologically active natural phytochemicals such as Moringa and Aloe vera extract, lavender, and Cinnamone oil, nanofillers such as ZnO@Ag, and GOx/Zn@hydroxyapatite nanoparticles which offer a promising solution to creating composite materials with enhanced performance.

The physicochemical characteristics of the developed matrices, as well as the added nanofillers, were characterized, and the preparation conditions in each case were optimized.

The In-vitro assessments demonstrate the potential applicability of the developed matrices and/or nanocomposites as scaffolds for bone and skin regeneration as well as innovative superabsorbent hemostatic and antimicrobial wound dressings reinforced with healing supplementary to promote and accelerate wound healing. To ensure their bio-applicability in the suggested field, several of the developed matrices have undergone In-vivo evaluation.

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Applications and Commercial Activities at JYFL-ACCLAB

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JYFL-ACCLAB, the Accelerator Laboratory of the University of Jyväskylä, is one of twenty-nine large-scale Research Infrastructures selected to be on the Finnish Research Infrastructure roadmap. Established in 1992, the laboratory currently hosts four accelerators providing ion beams from protons up to gold with energies in the range from MeV up to 22 MeV per nucleon. The facility can also provide electron and gamma-ray irradiations. These beams are provided by K130 and K30 cyclotrons, a 1.7MV Pelletron accelerator and an electron linac which was formerly used for therapy in a hospital. Whilst the main focus of the laboratory has been (and continues to be) on fundamental nuclear science, the laboratory has continually developed research programs in ion-beam analysis, radiation effects in electronic components and ion source technology. The expertise and technical developments of the various research groups are also exploited more broadly, with the laboratory providing a range of services for industries and users outside of the usual academic community. An overview of the JYFL-ACCLAB operations will be given, with particular emphasis on the applications for societal benefit.

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An irradiation platform to promote and disseminate the benefits of using electron accelerators.

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Electron beam or X-ray irradiation is a cold, residue-free physical treatment process that has been used for many applications for several decades. The effects sought on irradiated products are microbiological decontamination or sterilization, modification of the physico-chemical properties (surface or matrix) of materials, radical degradation of molecules of interest or radiochemical creation of neoformed molecules.

Aerial runs a platform of irradiation facilities based on electron accelerators, producing of low, medium and high energy electron and X Ray beams for studies, training and research projects on applications of current interest as well as innovative approaches to irradiation process control and dosimetry.

Indeed, new methods of process control and product release are currently being evaluated. The use of Monte Carlo simulations for operational and performance qualification of an electron beam or X-ray process is becoming increasingly realistic. Examples will be given.

The latest developments in dosimetry tools and their adaptation to low-, medium- and high- energy electron beams and X-rays will be presented.

The irradiator parameter-based release of the product from an electron beam irradiation process (RBIP) is attracting a great deal of interest in the irradiation industry. This new parametric release concept enables continuous control of the irradiation process by calculating and monitoring a "virtual dose" with a reduced amount of physical dosimetry. Advantages and limitations will be presented.

The radiation industry has changed over the past 35 years of Aerial's existence. The need to be better, more efficient, faster, healthier and more environmentally friendly has also evolved. Innovation is clearly necessary.

As an IAEA collaborating center, Aerial is open to hosting national/international collaborative R&D programs aimed at socio-economic benefits.

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4^{th} Generation High Energy Synchrotron X-rays: A Pivotal Large-Scale Tool with Socio-Economic Benefits

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Synchrotron X-rays, generated by relativistic electrons circulating through intense magnetic fields in advanced accelerator complexes, have become a pivotal analytical tool for both materials and living matter. Among user-based research infrastructures, synchrotrons are exploited by a diverse community of researchers, including those engaged in challenge-driven science and industry, with a significant socio-economic impact.

The European Synchrotron (ESRF) has recently completed its upgrade to become the world's first fourth-generation high-energy synchrotron X-ray source, serving nearly 10,000 researchers annually. The ESRF holds a prominent position on the European Strategy Forum for Research Infrastructures Roadmap and is recognized as a central pillar of the European Research Area. The exceptional brilliance and unique properties of the ESRF's X-rays open new avenues for scientific research, leading to emerging applications for a growing user base.

Recent ground-breaking research conducted at the ESRF has had novel socio-economic impacts. For example, multiscale imaging of human organs has revealed unprecedented insights into disease mechanisms. These results are accessible through "The Human Organ Atlas" (human-organ-atlas.esrf.eu), an open science and FAIR data resource available to all. This resource is being utilized for medical education, providing valuable insights and improving clinical diagnostics for medical scanners. The ultimate goal is to create a comprehensive micron-scale human model.

Other examples include research on battery safety and design, utilizing ultra-high-speed X-ray radiography and specific containment for real-time destructive battery testing, as well as high-throughput structural analysis in collaboration with an industrial partner to provide data for materialomics.

Worldwide, there are approximately 30 medium and high-energy synchrotrons. Building on the pioneering work of the ESRF, more high-brilliance synchrotron sources are planned globally, promising further advancements in the remarkable science produced by these facilities. Moreover, many countries and regions without direct access to a synchrotron are actively pursuing scientific, technical, and socio-economic justifications for establishing such facilities, recognizing their broad utility and impact.

Much of the work to exploit the ESRF's extremely brilliant source has been catalysed and enabled by the STREAMLINE project, which has received funding from the European Union's Horizon 2020 research and innovation programme under the INFRADEV grant agreement No 870313.

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Medical applications with heavy/radioactive ion beams at accelerator institutes

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Particle accelerator institutes have extensively contributed to biomedical research programs worldwide, which are of particular importance for their societal benefit and impact on human health. In this paper, some of the recent advances in the use of ion beams for medical applications will be discussed, with a specific emphasis on the research conducting in the Biophysics Department at GSI Helmholtz Center for Heavy Ion Research (Germany) as well as on the European community input received by NuPECC in light of the call for the Long-Range Plan 2024 under Thematic Working Group 7 “Applications and Societal Benefits”.

Ionizing radiation possesses the ability to directly damage the DNA structure of cells, by causing DNA breaks, which can ultimately result in cell death. This property has been used since many years for cancer treatment and sparked the interest of the nuclear physics research community to develop charged particle therapy at accelerator institutes at the end of last century. The technique exploits the Bragg peak of charged particles in order to reduce toxicity and improve local control compared to conventional X- ray based radiotherapy for cancer treatment. Cyclotrons and synchrotrons for charged-particle therapy are blooming worldwide and nowadays, the field is characterized by a fast succession of technological advances in additional to intense preclinical research programs on topics such as FLASH and spatially fractionated mini-beams with both protons and heavy ions. While the underlying radiobiological mechanisms of these new techniques are still a topic of active debate, several studies at GSI and other accelerator-based institutes have already illustrated that these novel beam delivery methods largely reduce normal tissue toxicity in animal models.

In parallel, several imaging techniques are making use of radiation properties to improve the diagnostics and the efficiency of a cancer treatment. This brings us to another, main medical application of accelerator produced beams, which is the production of radioisotopes for imaging, therapy, or both under the “theragnostics” umbrella. Major advances in theragnostics are expected by the introduction of α- particle and Auger electron emitting isotopes, due to their higher cytotoxic effectiveness to kill radioresistant tumor cells compared to more conventionally used β-emitters. Improvements in radiation dosimetry and genomic assessment of radiosensitivity will guide precision theragnostics to avoid both under-treatment and off-target toxicity.

Research in space radiation protection also needs accelerators to simulate the cosmic radiation that astronauts encounter in the space environment and particularly beyond lower earth orbit. In fact, most of our knowledge on radiation risk in space comes from experiments at ground-based particle accelerators. We are currently facing an era in which several new accelerator centres are under construction and existing facilities are upgraded. Those facilities will soon deliver their first beams of higher intensity and energy than we could ever produce before, and all these institutes have ambitious biomedical research programs that are innovative and potentially can lead to breakthrough discoveries. High energy is obviously important for to mimic high-energy cosmic rays for space radiation research but can also be useful for particle radiography in order to reduce range uncertainty in particle therapy. The higher intensity can also be a potential major breakthrough in particle therapy, where ultrafast treatments are convenient for clinical workflow and the mitigation of the problem of moving targets. Finally, radioactive ion beams (RIB), one of the main nuclear physics topics that justify the construction of new nuclear physics facilities, are potentially an extraordinary tool for cancer therapy as they allow the online visualization of beams during irradiation and for the production of novel radioisotopes.

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The ATOMKI Accelerator Centre serving science, technology, and innovation.

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The ATOMKI Accelerator Centre as one of the TOP50 research infrastructures in Hungary has a comprehensive list of low energy accelerators providing a wide range of charged particle species, charge states, intensities, and energies.

A radiocarbon dedicated Accelerator Mass Spectrometer (AMS) system provides further possibilities for science and technology such as analysis of honey and wine origin, or detection of anthropogenic carbon-dioxide. Micro- and nanobeam endstations are serving innovation-oriented research, eg nanofabrication for medical use. The standalone ECR ion source providing highly charged ions can be used for surface treatments of medical implants. Higher energy beams available at the ATOMKI cyclotron are used for industrial tribology studies as well as radiation hardness experiments. Isotope production station can provide isotope labeled molecules for health research.

The applications of those accelerators span different fields from astrochemistry to cultural heritage. The access to the accelerators is supported by several dedicated European networks such as Chetec-INFRA, EURO-LABS, EUROPLANET, etc.

We present the history, present status, and long rage plan of the facility with an emphasis on the socio-economic benefits including educational and outreach activities.

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Development of electron linear accelerators for societal applications

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Accelerator technology has come a long way from being an important tool for basic and applied research to catering to several societal applications. Accelerators have proven to be important for wide range of applications from medical to industrial, from security to environmental. The enormous potential of these accelerators was realised long back and Bhabha Atomic Research Centre (BARC), India has undertaken programs to indigenously develop electron accelerators for several applications related to all fields of our daily life.

With an objective to demonstrate radiation processing applications in several industries, BARC has indigenously developed electron accelerators with different energy and power rating to cater different varieties of products and the type of radiation processing. Two different accelerators namely 3 MeV parallel coupled self-capacitance type multiplier DC accelerator and 10 MeV RF Electron Linac are presently housed at Electron Beam centre, Kharghar. At BRIT Vashi, 500 keV Cockcroft Walton type multiplier DC accelerator is also employed for industrial irradiation. One of the main applications is related to plastic modification which is achieved through polymerization, grafting and crosslinking through radiation processing. Several products for example, PE granules from Reliance industry, Graft-polymerization for rubber tiles from SBC, paint curing on wood laminates etc. have been treated. Treatment of cloth fabric samples from Bombay Textile Research Association (BTRA) Mumbai for improvement of properties of cloth fabric has also been demonstrated.

Another very important utility of accelerators is for food irradiation. Variety of effects can be obtained by irradiating fresh foods. Low doses in the range of 0.1 to 1.0 kGy can inhibit sprouting of vegetables, disinfestation in cereals and legumes, disinfestation of parasites in fish and poultry and delayed ripening of some fruits. Medium doses can extend the shelf life of raw fish and sea foods as well as fruits and vegetables. This application is directly in line with the food security bill and has the potential to impact hugely socio-economic development of a country.

The accelerators can be also employed for environmental remedies. One of the greatest contributors of air pollution is the release of flue gas (SOx, NOx, CO2) in the atmosphere released by the thermal power plants and the industries. In one of the pilot projects of flue gas treatment has been carried out at our facility with electron beam treatment at I MeV. As a result of EB interaction with humid water droplets, highly reactive OH radicals are produced which react with the pollutants to produce sulphuric acid and nitric acids. The demonstration experiment was done in collaboration with BHEL Ranipet. Electron beam treatment of wastewater has the potential to remove harmful pollutants which are released by various industries like chemical, textile, refinery, foundry in urban area into the water bodies. This harmful to human population as well as marine life which disturbs ecology. For example, Azo-dyes used in the textile industries are among the most widely used synthetic dyes and usually become major pollutants in these wastewaters as these dyes are having complex chemical structure they cannot be degraded easily by ordinary chemical treatments.

A pilot study to evaluate the efficacy of electron beam irradiation induced degradation of textile dyes such as procion MX-8O (yellow) etc. has been carried out at EBC kharghar. Our current program includes developing a high-power electron accelerator (1 MeV, 100 kW) specially designed for Electron Beam Wastewater Treatment (EBWWT). Beside these, our accelerators have been also employed for electronic waste treatment. The irradiation of PCB was done with 10 MeV up to dose of 350 kGy for removal of copper.

Electron Linear accelerators (Linac) are used worldwide for medical treatment. The common applications that use medical Linac system are the "External Beam Radiotherapy" and the "Intra-Operative Radiation Therapy" (IORT), where the radiation is directly delivered at the treatment site during surgery. Currently, one of our programs is pertaining to the development of a compact 6 MeV medical electron linear accelerator (at X band) for radiation therapy. This Linac if realised will have a huge impact on the healthcare program of our country. Linac based radio therapy machines will be readily available and the treatment will be also cost effective.

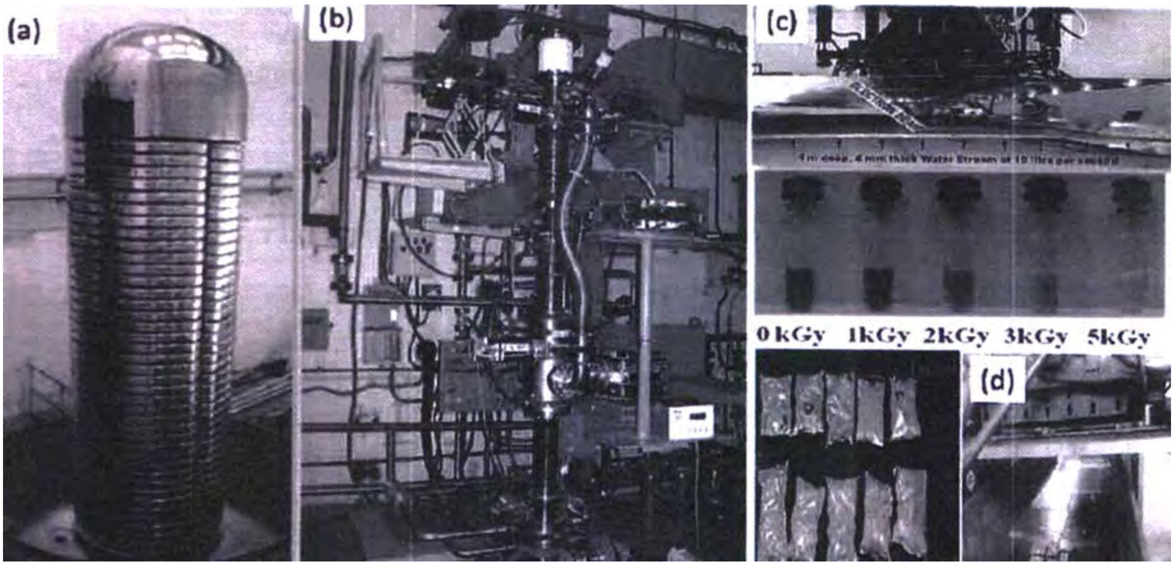

Figure: (a) HV column of3 MeV DC Linac at EBC Kharghar, (b)l0 MeV 2.856 GHz RF Linac at EBC, Kharghar, (c) Experimental Set Up and decolouration of dye (Bottom) with electron beam (d) Coriander Powder Irradiation in 10 MeV Linac at EBC

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Societal impact of Synchrotron radiation: the case of Elettra-Sincrotrone Trieste

Giuliana Aquilanti

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In 2022 Lightsources.org: the result of a collaboration between 25 member organizations around the world representing 30 light source facilities, 23 synchrotrons and 7 Free Electron Lasers (FELs), celebrated 75 years of Science with Synchrotron light [1]. In fact, the first direct visible observation of synchrotron radiation from a laboratory machine took place in a 70-MeV synchrotron at the General Electric Research Laboratory in Schenectady, New York, on the 24th of April 1947. Today there are more than 50 light sources in the world (operational, or under construction) with more than 7300 staff employed carrying out a huge range of experiments with applications in engineering, biology, materials science, cultural heritage, chemistry, environmental science and many more.

The exceptionally intense beams of X-rays, ultra-violet and infrared light produced at synchrotron radiation facilities, make possible both basic and applied research which are not possible with more conventional equipment. Many different kinds of sophisticated analyses, on a vast array of samples, can benefit from synchrotron radiation. These synchrotron techniques can be broadly broken down into three categories: diffraction (and scattering), spectroscopy and imaging.

The Italian non-profit company Elettra – Sincrotrone Trieste (figure 1) is a multidisciplinary research center of excellence specialized in generating synchrotron and free-electron laser light and applying the related state-of-the art experimental techniques for fundamental and applied research in all domains of materials and life sciences [2]. Its mission is serving international user communities to promote social and economic growth through basic and applied research. Since decades, Elettra - Sincrotrone Trieste is fostering coordinated research activities and know-how transfer through training, schools and workshops that have led to continuous increase in the number of users. Elettra – Sincrotrone Trieste was an IAEA Collaborating Centre in the period 2005–2014 and was again appointed in 2020 and has ongoing partnership agreements with UNESCO's International Center of Theoretical physics (ICTP) and many other Italian and foreign institutions [3]. This year Elettra – Sincrotrone Trieste celebrates 30 years of light and it is undergoing an ambitious upgrade plan designated Elettra 2.0.

Figure 1: Aerial view of Elettra - Sincrotrone Trieste (Credit: Elettra)

In the present paper I will do a brief introduction of synchrotron radiation highlighting those research works performed at synchrotrons with a remarkable societal impact. I will describe activities and achievements triggered by the Elettra – IAEA cooperation for what concerns the scientific knowledge, network effects and transfer of technologies.

References

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The Italian Centre for Oncological Hadrontherapy (CNAO): societal impact and sustainability

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CNAO (Italian acronym that stands for National Centre for Oncological Hadrontherapy) is a clinical facility, located in Pavia that has treated more than 4700 oncological patients with particle beams. These are protons and carbon ions, collectively named hadrons, hence the term hadrontherapy. Hadrons, in particular carbon ions, are more precise than conventional X-rays on the tumour target and possess radiobiological characteristics suited to treat radio-resistant or inoperable tumours.

This talk will deal with the rationale of hadrontherapy and will give an overview of its status in the world. It will also present the technologies associated to hadron beams production and their use, including accelerators, the dose delivery systems, the patient positioning, and the imaging devices. An overview of the most promising R&D topics is also included.

CNAO has been a case study used to evaluate and compare the costs and the benefits incurred by the existence of this infrastructure. The study has put in evidence costs and benefits related to health improvement, knowledge transfer, human capital, technological spill over and cultural outreach with a result, at the end of the period considered, of a high positive net present value of the centre. The cost-benefit analysis is also an important tool to support health policies strategies and assure a correct mechanism for reimbursement of hadrontherapy.

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BNCT activities in Japan and worldwide and their link to socio-economic impact

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In cancer treatment, minimally invasive treatment that reduces pain and side effects associated with treatment, preserves normal tissues and organs, and improves quality of life, as well as improving survival time and survival rate, are important factors. As cancer treatment, surgery, chemotherapy, radiation therapy, and immunotherapy are golden standard, and radiation therapy is expected to be a minimally invasive treatment method with a high quality of life. Boron neutron capture therapy, a type of radiotherapy, is a minimally invasive cancer therapy that uses the nuclear reaction between low-energy thermal neutrons (0.025 eV) and Boron-10 to kill cancer cells by generating alpha rays within cancer cells.

In Japan, accelerator based BNCT for unresectable locally advanced or locally recurrent head and neck cancer is started by health insurance in June 2020 at two locations, the General South Tohoku Hospital and Osaka Medical College Kansai BNCT Medical Center (KBMC). While conventional radiation therapy is administered once a day over a period of five times a week, BNCT is a single dose and has proven to be a safe treatment for cancer patients during COVID-19. In addition, a clinical trial of BNCT for skin cancer has been started at the National Cancer Center in November 2019, a specific clinical study of BNCT for recurrent malignant glioma after standard treatment at KBMC in June 2022, and a specific clinical study of BNCT for recurrent breast cancer after radiation therapy at Edogawa Hospital in July 2023. Clinical studies of BNCT have been started not only in Japan but also in China and South Korea from 2022.

I sincerely hope that the development of radiotherapy devices with higher precision, higher speed, and larger capacity will make it possible for anyone to receive advanced radiotherapy anytime, anywhere in an inexpensive, compact, and easy-to-use manner. The BNCT will contribute to solving problems related to technology, industry, health, and welfare, which are the goals of the SDGs.

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Science Opportunities at SESAME

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Agriculture, archaeology, biology, biomedicine, chemistry, cultural heritage studies, engineering, energy, environmental science, forensic science, geology, materials science, nanotechnology, new drugs, palaeontology, and physics are just some of the fundamental, applied, and industrial fields that are being revolutionised by the advent of advanced light sources.

The SESAME 2.5GeV storage ring, designed to store 400mA electron beam current, is accommodating now 300mA beam current with a good lifetime of around 24h. Two bending magnet and three insertion device beamlines are presently open to users, covering IR, soft X-ray and hard X-ray energy ranges.

The BM02-IR microspectroscopy offers the users a non-destructive vibrational technique that combines the spatial resolution of a microscope together with the high chemical sensitivity of the IR spectrometer. In addition to the SR-IR source broad spectral emission and the wavelength characteristics, Infrared Synchrotron provide advantages in its brightness/brilliance (about 1000 times brighter) with a signal-to-noise ratio that cannot be achieved by the conventional sources.

The BM08-XAFS/XRF beamline is dedicated to synchrotron-based X-ray Absorption Fine Structure (XAFS) and X-ray Fluorescence (XRF). The source is one of the bending magnets of SESAME, and the optical configuration consists of a vertical collimating mirror, a double crystal monochromator and a focusing mirror, allowing measurements in the energy range from 4.7 to 30 keV, covering most of the elements in the periodic table starting from Ti.

The ID09-MS/XPD beamline is dedicated to X-ray diffraction investigations from polycrystalline materials. Temperature-dependent in-situ measurements up to 1000 °C are possible using a gas blower, and the beamline can be used for a wide range of applications, such as phase identification and quantitative phase analysis, microstructural investigations, Pair Distribution Functions (PDF), grazing angle and reflectivity measurements.

The ID10-BEATS beamline for X-ray Computed Tomography (XCT) has been inaugurated in June 2023. Funded by a European Horizon 2020 project, the beamline allows for various operation modes and ensures sufficient photon flux density in a filtered white beam (up to 100 keV) or monochromatic beam between 8 keV and 50 keV.

The ID11L-HESEB beamline provide soft x-ray analysis techniques to understand the atoms' electronic structure and chemical environment. Soft x-ray techniques are surface-sensitive because soft x-rays have a high interaction probability with matters and can be applied to low atomic number elements that are critical for life science, like Carbon, Nitrogen, and Oxygen.

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Status and Beam Utilization of a Proton Linac at KOMAC

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The Korea Multi-purpose Accelerator Complex (KOMAC) operates a 100-MeV proton linac which was developed through the Proton Engineering Frontier Project from 2002 to 2012. Primary goal of this project was to support cutting-edge research as well as development in various industrial applications. The following philosophy was reflected in the development of the KOMAC 100-MeV proton linac and its beamlines to accommodate wide needs from the goal; a) satisfaction of beam users' specific demand on well-characterized proton beams from the proton linac, b) support on beam users effectively and efficiently, c) delivery of a sufficient number of proton beams for mass irradiation processing, and lastly d) future upgradability to a higher energy accelerator.

The 100-MeV proton linac is designed to deliver a high-intensity proton beam to be utilized in a wide range of R&D fields, including industrial applications. For effective support in various R&D projects with characterized beam requirements, the 100-MeV proton linac and several beamlines with target rooms are constructed. The proton linac consists of a 50-keV injector, a 3-MeV radio frequency quadrupole (RFQ), a 20-MeV drift tube linac (DTL)-I section, a 100-MeV DTL-II section, and a medium energy beam transport (MEBT) between DTL-I and DTL-II, which allows to extract 20-MeV proton beams to the target room for the low energy beam irradiation experiments as shown in Fig. 1.

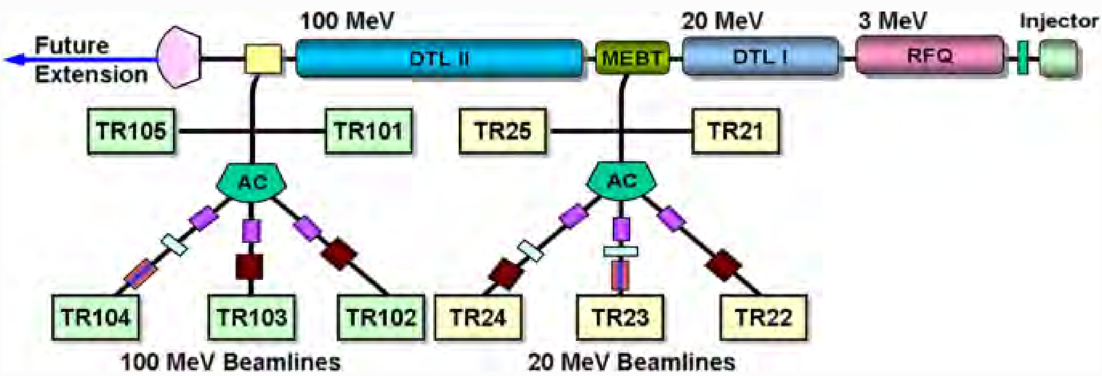

Fig. 1. Layout of the KOMAC 100-MeV proton linac, 20-MeV beamlines (TR21–TR25), and 100-MeV beamlines (TR101–TR105)

For various purpose of the beam irradiation experiments, we constructed ten target rooms: five 20-MeV beamlines (TR21–TR25) and five 100-MeV beamlines (TR101–TR105) also seen in Fig. 1. Each beamline can provide characterized beam of specific energy, current, repetition rate, pulse length to support user requirements.

- General purpose beamlines (TR23 and TR103): The 20 and 100 MeV general-purpose beamlines support research and development of semiconductor materials and nanomaterials in fields such as materials science and nanoscience.
- Beamline for isotope production (TR101): Developed exclusively for the production of medical isotopes, it is currently undergoing pilot operation, and research facilities such as isotope separation/purification are being built. It is planned to be used in the production of Cu-67, Ge-68, Sr-28, and Ac-225.
- Low dose beamline (TR102): An atmospheric/space radiation environment simulation test setup using protons evaluates the effects of atmospheric/space radiation on semiconductor devices and satellite

parts and components. It is also used for biological/medical researches and radiation detector characterization.

- Pulsed neutron pilot setup: The radiation effects of semiconductor devices has been evaluated on a pilot basis since 2018 using neutrons generated from a beam dump (1 kW class, Cu target).

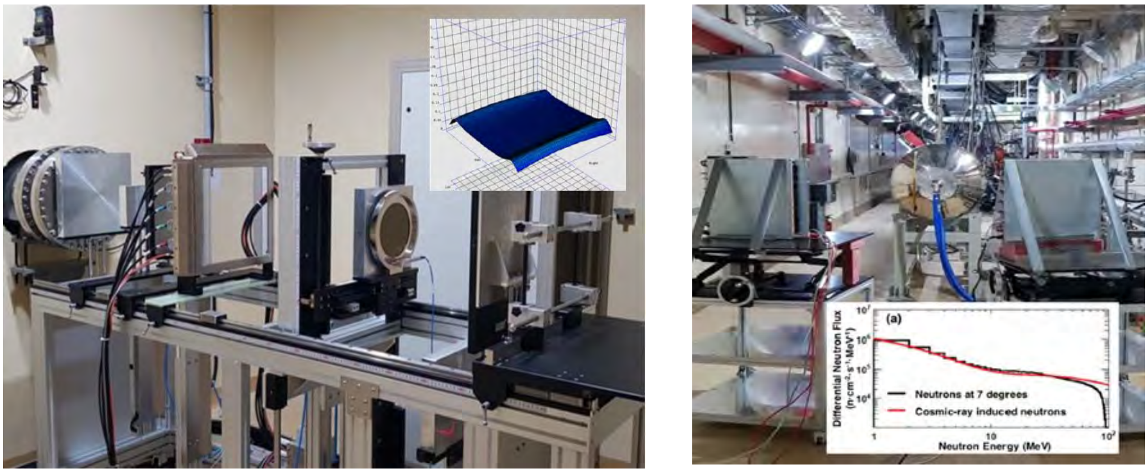

Fig. 2. Low dose beamline (left) and pulsed neutron pilot setup (right) at KOMAC.

There has been increasing demands on the use of proton beams for testing due to the local production of space components for next-generation small satellites and soft error testing in the semiconductor memory field. In addition, with the recent establishment of an international standard for automobile functional safety called ISO26262 related to autonomous vehicle technology, we expect more demands on accelerated particle effect experiments on semiconductors. At KOMAC, in response to the needs of the domestic semiconductor industry, space parts industry, and research institutes, we are utilizing a 100 MeV low-dose beamline and spallation neutrons generated from proton irradiation on a tungsten target (1 kW) for space/atmospheric radiation effect assessment. The low dose beamline and the pulsed neutron pilot setup are shown in Fig. 2.

Here, we present the status of the KOMAC 100-MeV proton linac and its beamlines supporting various R&D programs based on research demands from users and national strategic direction in Korea. One of the most successful contributions from the KOMAC accelerator is on semiconductor materials and devices. Detailed report on development of beam target rooms for semiconductors is also present. We have an energy upgrade plan on the proton linac from 100 to 200 MeV for the establishment of a proton accelerator-based fast neutron generation facility to widen its utilization fields, resulting in socio-economic benefits. The upgrade plan of the proton linac at KOMAC is also discussed.

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Accelerating Progress: Malaysia's Strategic Approach to Accelerators and Nuclear Science

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Accelerators, especially cyclotrons, have evolved into essential tools for advanced research and applications across various sectors, encompassing education, industry, healthcare, and agriculture. In Malaysia, the use of accelerators has played a pivotal role in advancing the nation's scientific and technological capabilities.

Through technology transfer, Malaysia has established electron beam machines with various capabilities, facilitating applications such as product sterilization, food preservation, material modification, and metallurgical processes. These accelerators have significantly enhanced industrial productivity and product quality.

Furthermore, Malaysia has experienced a growing application of accelerators in healthcare, with the establishment of five cyclotrons dedicated to nuclear medicine. Ten more facilities are up and coming in both private and public hospitals. These facilities produce radioactive materials essential for precise disease diagnosis and effective treatments in oncology, cardiology, and neurology. Cyclotrons are favored for their simplicity, utilization of stable and non-radioactive starting materials, and efficient waste management.

As Malaysia strives to become a progressive, inclusive, and sustainable nation by 2030, it recognizes the pivotal role of science, technology, and innovation (STI) in achieving its vision. The National Policy on Science, Technology, and Innovation 2021-2030 charts the path for Malaysia to become a high-tech nation by 2030, leveraging STI to enhance key socio- economic drivers.

Simultaneously, the recently launched National Nuclear Technology Policy (DTNN) 2021-2030 guides Malaysia in creating a vibrant nuclear technology ecosystem. This policy envisions Malaysia as a leading nation in the peaceful use of nuclear science and technology, contributing to global sustainable development.

To achieve these goals, Malaysia has outlined a series of strategic initiatives by 2030 to bolster its national infrastructure for accelerator technology and development, including regional expansion, diversification, public-private partnerships, and local capacity building.

To further anticipate future trends in accelerator-based technology, Nuklear Malaysia is currently preparing a Nuclear Foresight document for strategic planning and informed decision-making, ensuring that Malaysia remains at the forefront of advancements in this critical field.

In conclusion, Malaysia is actively leveraging accelerators and nuclear technology to achieve its national goals of becoming a high-tech, sustainable nation. The strategic initiatives outlined in the National Nuclear Technology Policy 2030, with a focus on accelerator technology, will play a pivotal role in driving economic growth, knowledge creation, and societal well-being while maintaining a commitment to peaceful and sustainable uses of nuclear science and technology. The successful implementation of this integrated approach, which combines supportive national policies, effective project management, forward-looking technology foresight, and strategic top-down research funding, is instrumental in unlocking the transformative potential of accelerator-based techniques. This comprehensive strategy not only accelerates scientific progress but also amplifies the realization of socio-economic benefits across diverse sectors, propelling nations toward a more prosperous, sustainable, and promising future.

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Development of novel fields of electron beam accelerators applications – INCT perspective

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Ideas about how ionizing radiation could benefit humanity emerged soon after the first discoveries. However, the further development of ionising radiation sources was needed to start development of commercial applications of electron beam accelerators for different industries in the 50-ties of XX century and is still an area of research. There are technologies, where the use of the electron beam is an essential step of the production processes such as cross-linking of cable insulations, production of thermos-shrinkable materials, and pre-vulcanization of tires. Apart from well-developed technologies, there are many other applications where electron beams can be used but still development is needed.

Institute of Nuclear Chemistry and Technology is a leased in research and implementation of electron beam accelerator-based solutions, which are beneficial for humans and environment. The infrastructure available at INCT, including 4 electron beam accelerators providing a beam of electrons of energy from 200 keV up to 10 MeV with its additional equipment, provides a versatile platform to carry out research and pilot scale irradiation for various applications. Implementation of such technology as microbial decontamination of food products aimed to increase food safety and reduce the number of food poisonings and food losses. Also developed medical sterilization with electron beam was successfully implemented including not only treatment of single use medical devices but also novel products such as hydrogel wound dressings or tissue allografts. The properties of the electron beams to inactivate living organisms can also find other applications, e.g., in agriculture (elimination of plant pathogens, parasites) to protect crops and increase crop yield or to help to utilize agriculture and food production wastes, by elimination of microorganisms from sees, elimination of biological contaminates sludge for use as fertilizer or by disintegration of organic wastes for biogas production.

With the increasing awareness on the negative influence of different contaminants on environment also application of electron beam to eliminate chemical contaminants is an interesting area of research. It was already proved that electron beam can be used to eliminate SO_2 and NO_X for flue gas or to decompose chemical compounds in water. Facing the increasing need for a circular economy electron beam can be also a useful tool to help to recycle fossil fuels-based materials or to obtain functioned materials for their use as sorbents.

As application of electron beams can help to eliminate the use of harmful chemical compounds (e.g., elimination of ethylene oxide use) to protect the environment. The great advantage of electron beam-based technologies is that no radioactive materials are used, and due to current developments in the construction of electron accelerators, it can be used as a self-shielded unit that can safely operate in any facility or any location. Electron beam provides a veritable tool, that can be used to help achieve Sustainable Development Goals (SDGs), related to human nutrition and food safety, a cleaner environment, clear water, and sustainable production.

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Research at the Portuguese Ion Beam Laboratory

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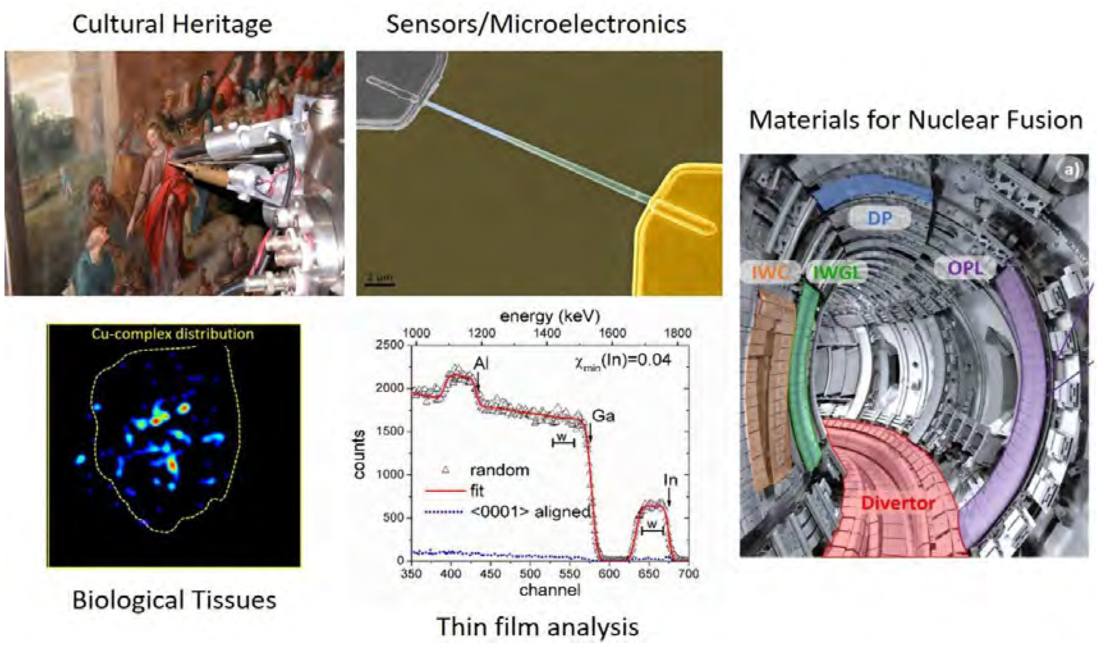
Small and medium size accelerators running in laboratories located at universities and research institutions around the world provide a powerful platform of nuclear techniques for multidisciplinary research in several domains. Furthermore, they play a major role in keeping and providing knowledge in Nuclear Science and training the new generations. This presentation will give an overview of the ion beam facilities installed at Instituto Superior Técnico of the University of Lisbon. These include two electrostatic accelerators and a high flux ion implanter that are devoted to multidisciplinary research as well as education and training students in nuclear-based experimental techniques. Research is carried out in areas with high societal impact including materials science and nanotechnology, energy, biomedical and environmental sciences, cultural heritage, among others [1].



Examples of multidisciplinary research at the Portuguese ion beam laboratory

[1] Alves et al., An insider view of the Portuguese ion beam laboratory, Eur. Phys. J. Plus (2021) 136:684

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Enhancing Medical Diagnostics in Endoprosthesis Failure Cases with Particle Induced X-ray Emission (PIXE)

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The application of ion beam analysis, particularly Particle Induced X-ray Emission (PIXE), has emerged as a ground-breaking approach to enhance diagnostics in cases of endoprosthesis failures. This innovative application of accelerator-based techniques not only supports the development of more precise diagnostics in failure cases but also aids in the creation of improved endoprostheses with reduced failure rates. Traditional diagnostic methods employed in hospitals, such as X-ray scans and optical tissue microscopy, can identify metal particles but fall short in identifying their specific metallic origin (e.g., Ti, V, Al) and concentration.

At the Jozef Stefan Institute, we initiated the multidisciplinary Marie Curie project "TissueMaps"[1], where PIXE has played a pivotal role in advancing diagnostics, by mapping the distribution and quantification of metallic particles released from deteriorating prostheses. This capability allows us to identify the specific prosthesis component responsible for the failure and determine the extent of the issue. Our Micro-beam end station at the Jozef Stefan Institute's 2MV tandem accelerator is especially suited for this type of research. It offers a high-brightness proton beam (14 A m^{-2} rad^{-2} eV^{-1}), enabling a reduction in the beam size through a smaller object-slit aperture and acceptance angle. Moreover, its exceptional elemental sensitivity, with a detection limit as low as 0.1 μgig, and a lateral resolution of 600 nm, make it ideally suited for these experiments.

The initial "TissueMaps" was a collaborative project between the Jozef Stefan Institute and the University Medical Centre Maribor, both in Slovenia, supported by Marie Sklodowska-Curie Actions. Our research has since expanded, first thanks to the RADIATE Transnational Access[2] program, to include new clinical cases from Switzerland and, more recently, with a new collaborative project with Germany.

The global demand for hip replacements is on the rise, with approximately one million procedures performed annually. This increase is attributed to greater life expectancy and an aging population. Amid the escalating utilization of endoprostheses, PDCE may serve as a pioneering technique that not only enhances diagnostic precision but also plays a pivotal role in the continual refinement of endoprosthesis design and production. This contribution may have an impact on improving the well-being and quality of life for numerous individuals.

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[1] This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No. 799182.
[2] https://www.ionbeamcenters.eu/radiate/radiate-transnational-access/

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Elemental analysis of edible plants with accelerated ion beams

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For elemental quantification and localization, Ion Beam Analysis (IBA) methods and techniques utilizing accelerated ion beams at Jožef Stefan Institute (JSI) in Ljubljana, Slovenia, is frequently used for biological material research. By exploiting specific phenomena from interaction of an accelerated particle with material in question a variety of information can be obtained. IBA techniques most frequently used are Proton Induced X-ray Emission (PIXE), Scanning Transmission Ion Microscopy (STIM) and Rutherford Back-scattering Spectroscopy (RBS). These methods are being continuously exploited in many plant-related research projects for many years.

MicroBeam-PIXE was used for determination of arsenic, cadmium, and lead in *Typha latifolia* for studying plant ionomics [1]. Similar research also covers general distribution of nutritional and mineral components in important crop plants [2, 3], elemental distribution of elements in tea [4], barley [S] and hyperaccumulation properties of lead in *Arabidopsis halleri* [6] etc.

The general research and its socio-economic aspect with accelerated ions at JSI used for mineral quantification and distribution in edible plants is presented together with future outlook for further research and development.

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Research facilities and highlights at the Centro Nacional de Aceleradores (CNA)

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The Centro Nacional de Aceleradores is a user-oriented accelerator facility in Seville, Spain. Its main facilities are a 3 MV tandem accelerator, an 18 MeV proton Cyclotron, a tandetron used for AMS, a compact accelerator used for radiocarbon measurements, a ^{60}Co irradiator and a PET/CT scanner. The technical specifications and research applications of these facilities are described. A neutron beam line associated to a charged pulsed beam in the tandem allows for time of flight measurements which determine the neutron energy. The use of an adequate stripper gas in the AMS tandetron permits to measure heavy radionuclides with very low detection levels, allowing performing environmental studies using these radionuclides as tracers. The use of the microbeam in the tandem accelerator allows applying the ion beam-induced current technique to investigate the spectroscopic properties and radiation hardness of different semiconductor detectors.

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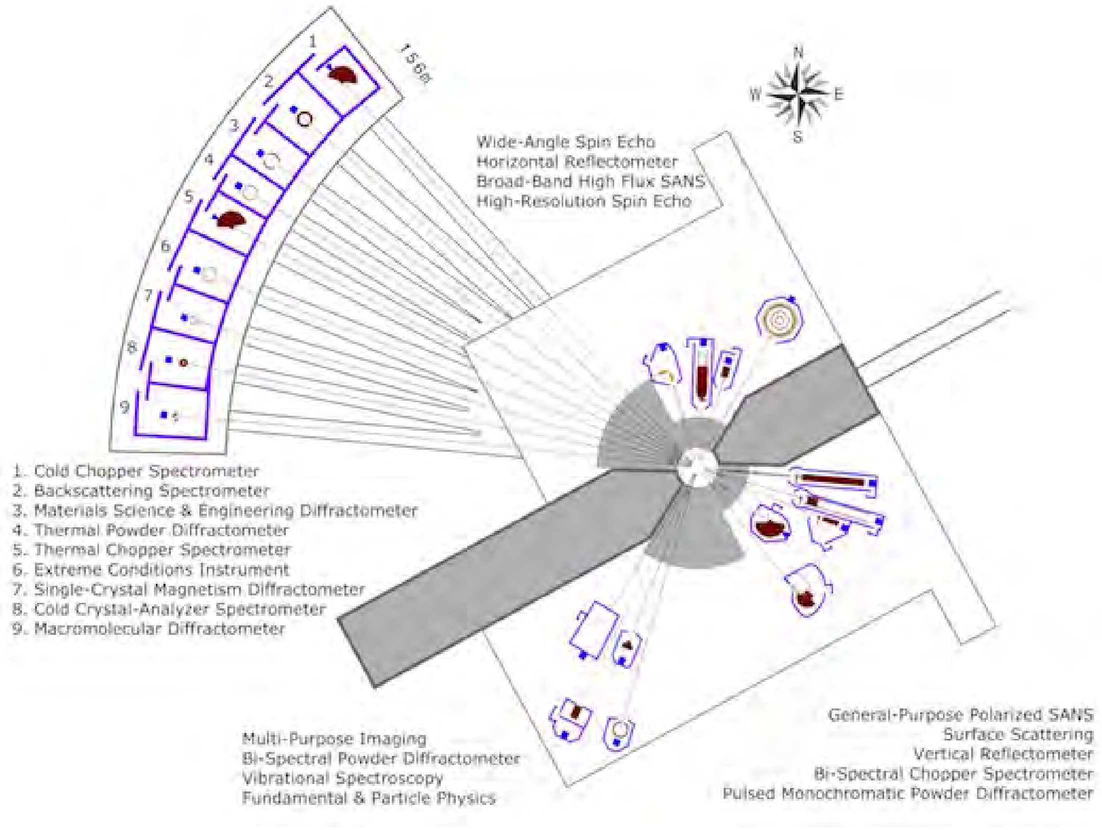
ESS: from protons to neutrons, the accelerator science improving daily-life.

M. Juni Ferreira, M. Lindroos

European Spallation Source ERIC, Lund, Sweden

The European Spallation Source (ESS) represents a multi-disciplinary research infrastructure for neutron studies, centered around a 2 GeV-5 MW proton linear accelerator (LINAC), representing the latest advancements in accelerator science. This facility aims to be the brightest neutron source, paving the way for innovative research across diverse domains such as biology, environmental technologies, materials science, and fundamental physics. At the core of ESS's capabilities are its Super-Conductive Radio-frequency cavities (SRF), which accelerate a proton beam to induce neutron production through the spallation process on a helium-cooled tungsten target. With the capacity to accommodate 42 neutron instruments, the first phase will host 15 instruments. All instruments are designed to offer groundbreaking scientific capabilities not currently available at existing facilities, maximizing the breadth and depth of the scientific impact during the early years of ESS. This will provide a robust foundation for the completion and future expansion of the facility, contributing positively to daily life and advancing the frontiers of human knowledge. The ESS will enable various research possibilities, including but not limited to those in the fields of biology, environmental technologies, materials science, and long-term high-energy physics. This expansion of research areas demonstrates the versatility of the proton accelerator, opening up new avenues for exploration and discovery.



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The Radiological Research Accelerator Facility at Columbia University

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The Radiological Research Accelerator Facility (RARAF) at Columbia University[1] is dedicated to understanding the radiobiological mechanisms by which ionizing radiation affects living tissue. Founded in 1967 to provide monoenergetic neutron beams for radiobiology and microdosimetry studies, RARAF has expanded to provide a broad palette of radiations well suited to studies in radiation protection, Space Radiation, development of radiation countermeasures and cancer therapy.

A) CANCER - RELATED STUDIES

Since its inception, RARAF Researchers have focused on developing improved tools for treatment of Cancer. Today, we focus on two emerging modalities: FLASH radiotherapy and heavy ions.

- *FLASH radiotherapy*

Conventional radiotherapy delivers dose to the tumor at dose rates of a few Gy/min with every effort made to increase conformality, reducing radiation delivered outside the tumor volume to reduce adverse effects in the healthy tissue. Recently, it has been shown that if dose rate is increased to roughly 100 Gy/sec, delivering the treatment in a fraction of a second, the adverse effects in the healthy tissue are much reduced without compromising tumor killing.

To further investigate this so-called FLASH effect, we have modified a medical linear accelerator to allow irradiation of tumor bearing mice, at dose rates of 100 Gy/sec or more[2]. Following FLASH irradiation of brain tumor bearing mice, we have seen reduced cognitive decline compared to conventional dose rates at the same level of tumor killing. Other cancer types are under investigation.

- *Heavy ion radiotherapy (HIRT)*

A second promising modality is the use of heavy ion beams and in particular carbon to treat cancer. From patient results it appears that HIRT may also be inducing long-range systemic anti-cancer effects. RARAF provides ion beams with a range sufficient to irradiate cellular monolayers, targeting cellular or sub-cellular objects or very thin tissues. Hydrogen and helium beams with LET ranges of 10-150 keV/µm are offered in micron to cm sizes and carbon boron and lithium beams (LET range of 200-1000 keV/µm) are coming online. at spot sizes of 1 µm to a few mm. The recent installation of a linac booster allows irradiation of thicker samples beams enabling irradiation of thin tissue samples in addition to cell cultures.

B) RADIATION BIODOSIMETRY AND COUNTERMEASURES

Response to a large radiological event will require mass application of biodosimetrical assays, both to identify those individuals who would benefit from treatment in what is sure to be a resource-limited scenario, and to reassure the large number of worried well. RARAF provides a broad range of novel irradiation platforms that allows testing these assays using radiation fields mimicking those expected, for example, from an improvised nuclear device.

- *Neutrons*

The **C**olumbia **I**ND **N**eutron **F**acility (CINF)[3], is a novel accelerator-based neutron source with an energy spectrum modeled on the Hiroshima atomic bomb spectrum at a survivable distance from the epicenter. Beams are generated by impinging a mixed proton/deuteron beam on a beryllium target, generating a broad-spectrum neutron beam peaked around 1 MeV. Mice and tissue samples can be irradiated at a dose rate of up to 3 Gy/h.

Research at RARAF has shown that the standard cytogenetic assays used for biodosimetry are more sensitive to neutrons, showing yields equivalent to a 3-4 times higher gamma dose. CINF has also allowed development of transcriptomic and metabolomic signatures that are characteristic to neutron exposures.

Ongoing research focuses on testing various radiation countermeasures, developed to treat photon exposures, under realistic neutron and mixed photon-neutron exposures.

The neutron energy spectrum obtained is also a good model for space radiation such as lunar albedo neutrons and has been used to investigate risk to astronauts on long-term missions[4,5].

- *Ultra High dose rates*

A major part of exposure from an IND will be delivered very rapidly, over a time scale of microsecond to milliseconds. As noted above the FLASH effect has the potential to modulate effects in healthy tissue above dose rates of a few 10s of Gy/sec and will likely play a role in an IND scenario. Our FLASH irradiator allows mimicking these exposures delivering 2 Gy of radiation or more in a single microsecond-scale pulse. Ongoing studies are investigating the effects of these extremely high dose rates on various radiation induced diseases and on the efficacy of radiation countermeasures.

- *Ultra low dose rates*

On the other end of the spectrum, radiation from fallout is delivered at very low dose rates over several days. The VAriable Dose-rate External ^{13}7Cs irradiatoR (VADER)[6] allows modeling of low dose rate exposures in mice and other samples using repurposed ^{137}Cs brachytherapy seeds to generate low dose rates (0.1 to 1 Gy/day), mimicking fallout and ingestion exposures. Within the VADER, up to 15 mice can be housed in an IACUC approved "mouse hotel" for a few weeks. A custom incubator is available for performing ex-vivo blood (or other tissue) irradiations.

During the more than 50 years that RARAF has been in operation, experiments have been performed for over 50 different research groups from more than 40 institutions worldwide, including universities, national laboratories, cancer centers, and private corporations. These experiments, performed with radiations such as protons, alpha particles, electrons and neutrons, have resulted in more than 200 publications in refereed journals, proceedings, and books.

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Case Study Methods for Estimating the Socio-Economic Benefits of Accelerator-Based Techniques

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Communicating the socio-economic benefits of accelerator-based techniques is vital to ensuring that sufficient investment in accelerators is secured now and in the future. Accelerators require substantial up-front investment followed by consistent, long-term appropriations for operations, maintenance, and upgrades. These investments are worthwhile because accelerator-based applications generate substantial socio-economic impact across a broad range of topics and challenges that are of global importance. However, while investment requires direct monetary contributions from a discrete number of investors, socio-economic benefits are often broadly distributed and not naturally monetized. Hence, the return on investment to accelerator-based research is not always clear or straightforward to communicate.

Varied and innovative approaches are needed to assess the economic returns to accelerator-based techniques. As noted in the information sheet for this technical meeting, "accelerator-based applications cover almost all areas of life."[1] Consequently, impact mechanisms vary drastically for each application. Further, there are often limited or no comparative scenarios for estimating the socio-economic benefits of revolutionary applications. As such, researchers estimating the socio-economic benefits of accelerator-based techniques must draw from a variety of economic impact estimation methods, including market analysis, benefits transfers, and stated or revealed preference methods. Using a mixed-methods approach can fill quantitative data gaps with qualitative inputs, and providing threshold assessments and multiple impact scenarios can clarify the influence of qualitatively-driven modelling assumptions on study results.

RTI International, a non-profit research institute headquartered in North Carolina in the United States, is conducting a perspective and prospective economic impact assessment of U.S. federal neutron scattering research facilities, including both reactors and accelerators. The assessment is being funded under a cooperative agreement from the U.S. National Institutes of Standards and Technology and seeks to provide a knowledge base from which investment and action can be launched. We focus on technology transfer to the private sector; facility access and usage; and consequent impacts on economic growth, and collaboration between federal labs, universities, and the private sector. A key part of this assessment entails completing case studies of key technologies influenced by neutron scattering research.

I present four case studies that entail both perspective and prospective analyses using a range of assessment techniques. First, we look at the discovery of giant magnetoresistance through polarized neutron reflectometry and its application to advances in hard drive technology.[2-4] Second, we look at two aerospace applications that increase the safety of aircraft travel: the use of small angle neutron scattering to develop a fuel additive with reduced flammability,[5-6] and the use of neutron diffraction for identifying residual stresses in aircraft components to improve aircraft structural integrity.[7-9] Next, we estimate the impact of adopting new weight loss drugs whose development was influenced by small angle neutron scattering by modelling changes in U.S. obesity levels.[10-12] Finally, we look at the influence of multiple neutron scattering techniques on improving electric vehicle performance.[13-14]

These case studies rely on multiple assessment methods as appropriate to each application. We draw on existing literature and expert elicitation to identify the realized or potential impacts of each technology. Quantitative assessment methods include market analysis, counterfactual analysis, and health outcome modelling. Where direct market information is not available, we apply benefits transfers to estimate the economic values associated with various realized or hypothetical outcomes, i.e., the value of reductions in U.S. obesity rates, aircraft incidents, or greenhouse gas emissions.

Together, these case studies suggest that multi-billion-dollar socio-economic benefits from technologies enabled by neutron scattering research in the United States are realized each year. The case studies also demonstrate the innovative approaches needed to estimate the socio-economic benefits of cross-cutting applications of complex research techniques, as is the case for other accelerator-based techniques.
Conducting multiple impact case studies of accelerator-based techniques using common research and accounting standards would enable the aggregation of results to provide lower-bound estimates of the socio-economic benefits generated from accelerator-based techniques worldwide.

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Accelerating Solutions for Society; Synergies of Discovery Science and Applications at the Texas A&M Cyclotron Institute

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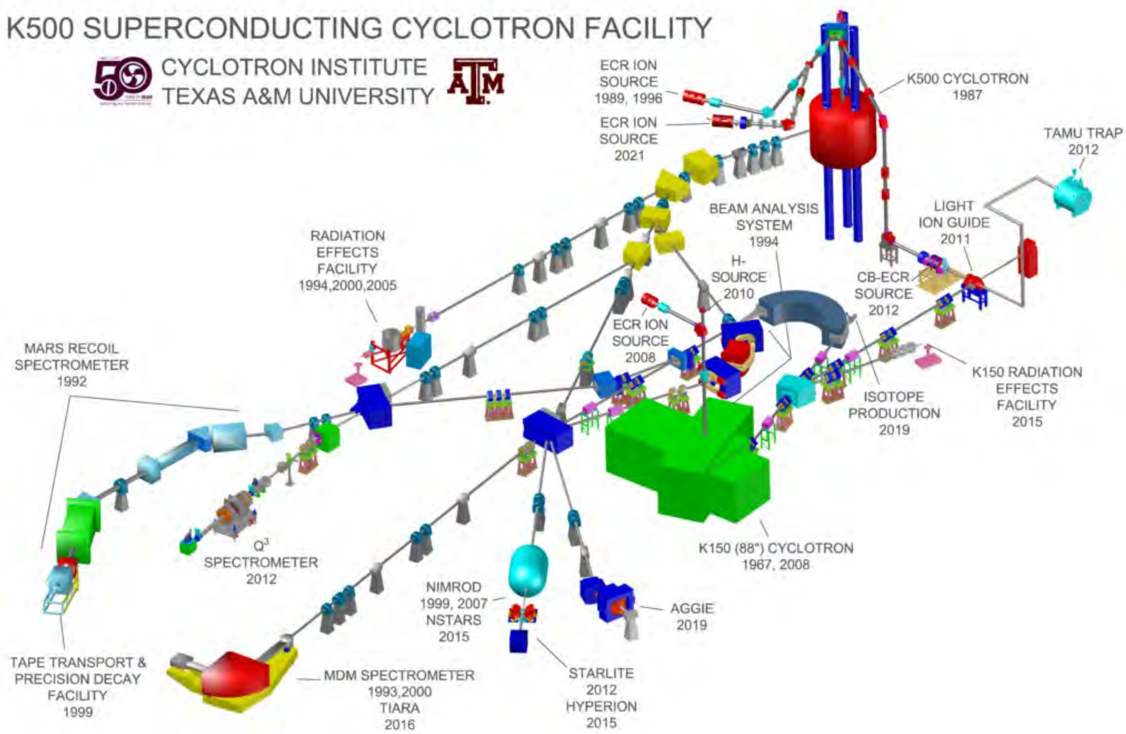
The Texas A&M Cyclotron Institute operates two cyclotrons, a K150 cyclotron and a K500 superconducting cyclotron. Both cyclotrons were constructed and operated for decades for discovery science. However, the Cyclotron Institute has expanded its benefits to society by also providing beams for testing the effects of radiation on electronic systems and for production of medically relevant isotopes.

Initially started on the K500, but now operating on both cyclotrons, is the Radiation Effects Facility (REF). The Cyclotron Institute's REF provides a convenient and affordable solution to commercial, governmental, and educational customers in need of studying, testing, and simulating the effects of ionizing radiation on electronic systems. The facility features a dedicated beam line with diagnostic equipment for complete dosimetry analysis and beam quality assurance. A beam energy degrader system allows for a change of linear energy transfer (LET) without cyclotron returning or target rotations. The cyclotrons, in combination with advanced ECR ion sources, allow for the acceleration of ions to energies as high as 60MeV per nucleon. Featured at the facility is a set of 15 MeV/u ion beams. These beams provide a broad LET range of 1 to 93 MeV*cm/mg in silicon at normal incidence and allow for quick ion changes. For greater range needs, two sets of higher energy beams (24.8 MeV/u and 40 MeV/u) are also available.

The K150 cyclotron also provides beams of alpha particles to produce At-211. At-211 is an alpha emitter of considerable interest for the emerging cancer treatment modality of targeted alpha therapy (TAT). Alpha emitting radionuclides with medically relevant half-lives are interesting for treatment of tumors and other diseases because they deposit large amounts of energy close to the location of the radioisotope. The properties of 211At make it a great candidate for TAT for cancer due to its short 7.2-hour half-life.



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IAEA activities in support of sustainable development of accelerator facilities and the IAEA Ion Beam Facility Project

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Due to their unique analytical and irradiation capabilities, ion beam accelerators play a major role in solving problems of modern society related to environmental pollution and monitoring, climate change, water and air quality, forensics, cultural heritage, agriculture, development of advanced materials for energy production via fission or fusion, and many other fields. Moreover, particle beams delivered from almost 20.000 accelerators worldwide are used for industrial applications and high-tech services resulting in business revenues in the billion-dollar scale, which clearly demonstrates the decisive contribution of particle accelerators to the increase of competitiveness of economies worldwide and the welfare of modern society in general. For all these reasons, accelerator-based applications are among the thematic areas, where the International Atomic Energy Agency (IAEA) supports its member states in strengthening their capacity to adopt and benefit from the use of accelerators. In this context, the IAEA Physics Section implements various activities in support of accelerator-based research and applications that focus on

- promoting the utilization of accelerators in support of applied research in almost all fields with high societal and economic impact,
- enhancing utilization of existing accelerator infrastructures by enabling facility access for scientists from developing countries without such facilities,
- assisting scientists from developing countries in carrying out feasibility and infrastructure assessment studies and establishing new accelerator facilities.
- assisting Member States in installing, operating and maintaining their accelerator facilities and associated instrumentation

In addition to the aforementioned activities a feasibility study for an ion beam accelerator facility (IBF) at the IAEA laboratories in Seibersdorf was performed in order to assess the interest of Member States in using this facility. Forty Member States have quantified their needs through replies to a properly designed questionnaire. The analysis of the questionnaires showed high demand in training in accelerator technologies and associated Ion Beam Analysis (IBA) techniques, as well as in analytical services in almost all areas of IBA applications. An appropriate accelerator design, matching the IAEA's programme for capacity building and provision of products and services across many fields of interest for the Member States, was identified.

Under these developments, the need of a project aiming at establishing an ion beam facility at Seibersdorf was justified. The main objective of the IBF project is to establish a state-of-the-art accelerator facility at the IAEA laboratories in Seibersdorf to cover the identified Member States' needs for training scientists and engineers in operating and applying ion beam accelerator technologies and to provide a range of associated services. The expected outcome of the project is to enhance the capacity and capability of the IAEA to address the rising demand of Member States to provide assistance in promotion of applied research using accelerator technologies for a large variety of medical and industrial applications.

This presentation aims at disseminating the IAEA tools and activities in support of accelerator-based research and applications are implemented. Moreover, details on the feasibility study, the instruments, and facilities to become available through the IBF project, including preliminary estimates of the resources, will be presented.