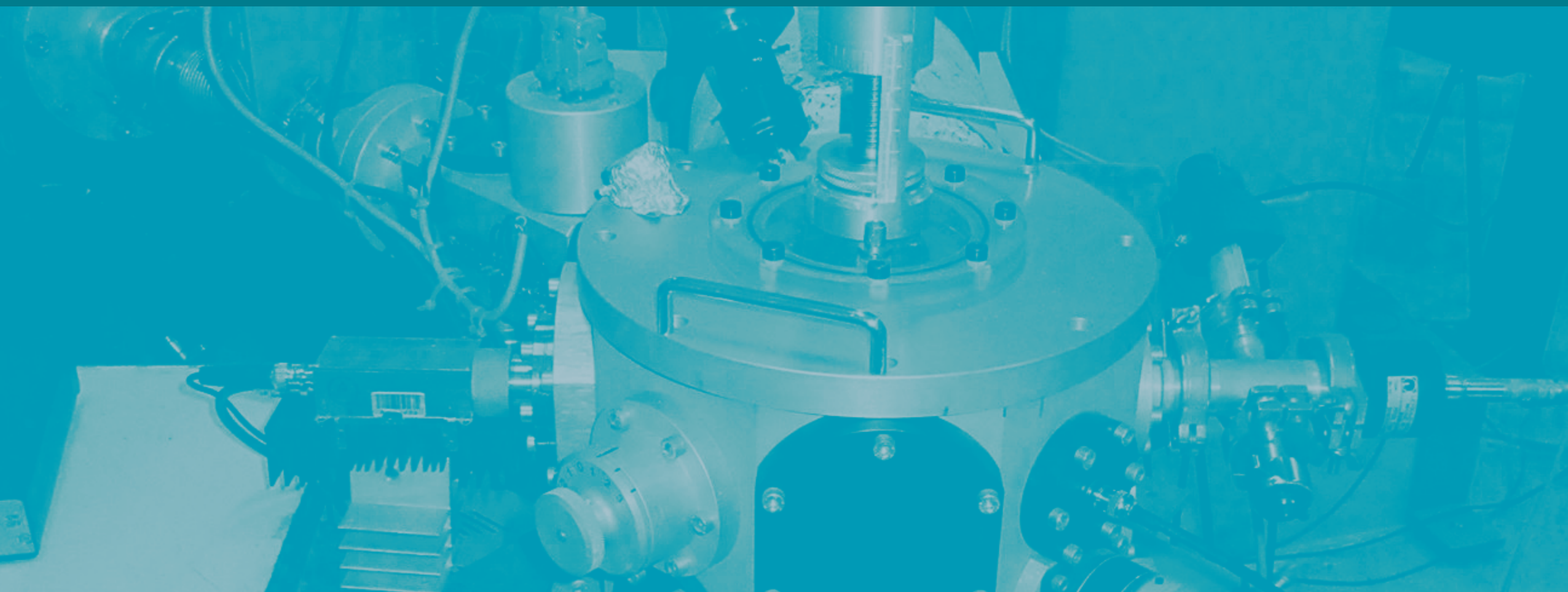
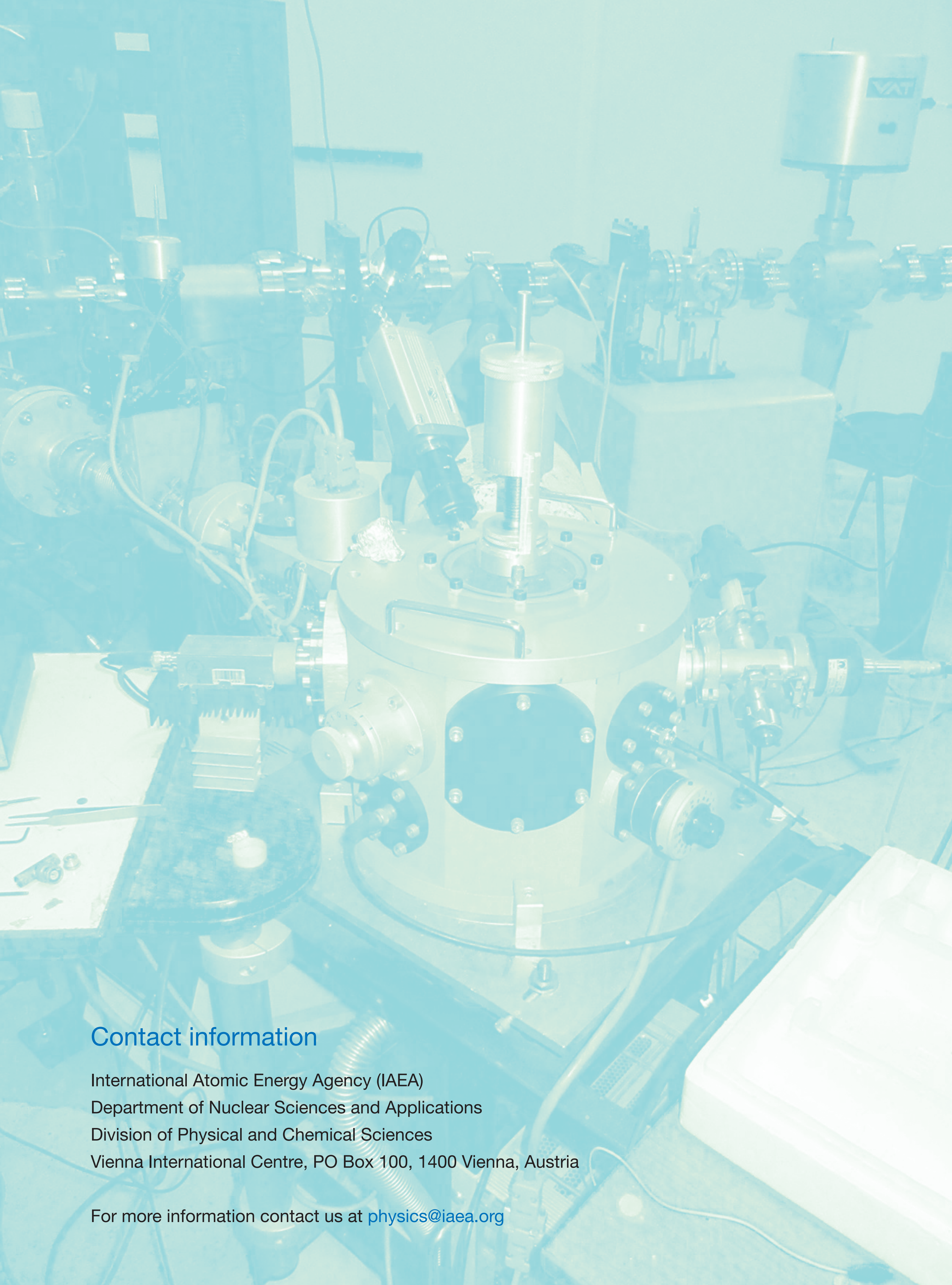
ION BEAM ACCELERATOR PROJECT

CALL FOR EXTRABUDGETARY SUPPORT



IAEA
International Atomic Energy Agency



Contact information

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Key areas of work

The IAEA Physics Section in the Department of Nuclear Sciences and Applications implements the *Accelerator Applications and Nuclear Instrumentation* sub-programme through the Nuclear Science and Instrumentation Laboratory (NSIL).

NSIL is located in Seibersdorf, Austria. The laboratory helps Member States to strengthen their capabilities to adopt and benefit from the applications of accelerators and nuclear instrumentation, and to assist related Technical Cooperation Projects.

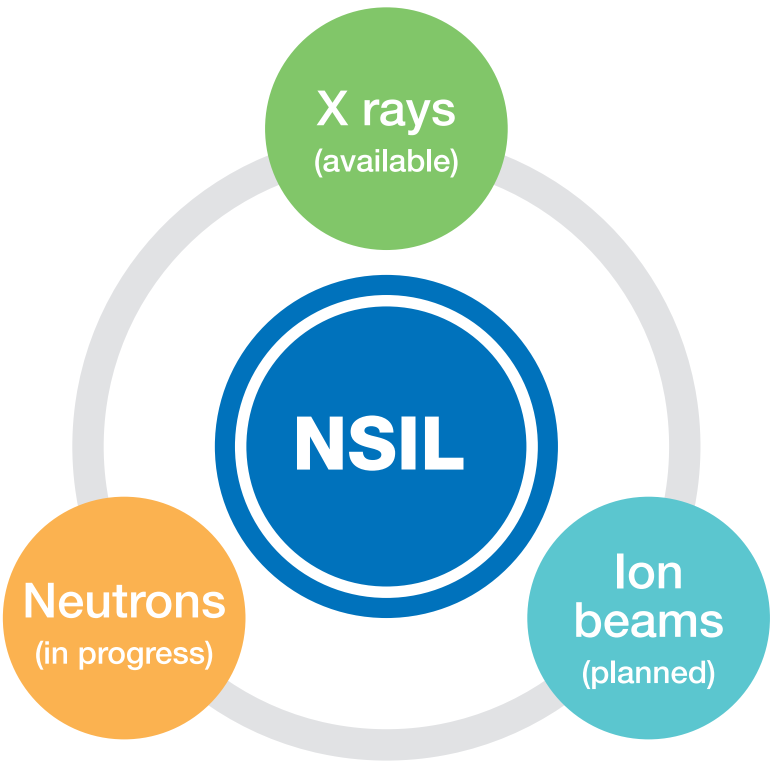
For more than 30 years, NSIL has supported capacity building in IAEA Member States through the effective use and development of nuclear instrumentation and nuclear spectroscopy techniques in a variety of peaceful applications using adaptive research, services and training activities.

NSIL uses or intends to develop three complementary probes for irradiation and analysis:

- **X-rays** – using existing facilities;
- **neutrons** – thanks to the upcoming neutron science facility with deuterium-deuterium and deuterium-tritium neutron generators;
- **ion beams** – through the planned establishment of an ion beam accelerator.

NSIL aims to establish a compact state-of-the-art ion beam accelerator in Seibersdorf for:

- Capacity building through education and training;
- Promotion and support of applied research;
- Provision of specialized services both to internal and external users.



Ion beam accelerators: tools for socio-economic development

The most well-known applications of accelerators are in the production of radioisotopes and creation of intense high energy gamma sources for irradiation purposes.

Compact electrostatic ion beam accelerators, such as tandems, are of growing interest in research and industry because of the increased analytical and irradiation services of the ion beams they provide. They have various applications in areas as diverse as cultural heritage, biomedicine, forensics, food and agriculture, water and air quality, advanced materials' development, radiation damage studies and industry.

Accelerators benefit scientific research, contribute to socio-economic development and provide a bridge to the high-tech sector.

Basic methods for using ion beams as analytical probes

Ion beam accelerators are machines providing kinetic energy to charged particles called ions, which bombard the target sample – the material to be irradiated and subsequently analyzed. The target can be a thin foil or a piece of mineral, rubber, textile, tissue, soil or metal. The sample can be an object such a painting, a statute, or even a bullet. Certain nuclear and atomic physics phenomena are then used to investigate the structure, composition, age or other important properties of the analyzed material.

IAEA Physics Section's expertise in accelerator technologies

The IAEA Physics Section has demonstrated in-depth knowledge and skills in setting-up, steering and supporting projects related to ion beam accelerators in developing countries. The Section facilitates hands-on trainings in accelerator operations and maintenance, and assists in refurbishment and modernization of beam lines and associated instrumentation. The Section assists Member States by providing:

- feasibility and design studies;
- business and strategy plans;
- technical support in specifications, procurement, installation, repairs and upgrades of accelerator and experimental devices;
- training of scientific and technical personnel.

Feasibility study

A comprehensive feasibility study for the establishment of an ion beam accelerator has been performed to assess whether and, if so, how the acquisition and operation of an accelerator in Seibersdorf could match the NSIL's mission and existing programme for capacity building as well as the provision of services across many fields of relevance to the IAEA and its Member States. The full feasibility study report is available on request. Main sections of the report are highlighted below.

Stakeholder analysis and users' needs

The analysis of countries' current needs for training and ad hoc services, such as access to particle accelerators, was conducted based on the evaluation of interviews given by IAEA internal stakeholders and a questionnaire completed by external stakeholders.

More than 60 replies from almost 40 Member States were received. They showed that most commonly demanded topics include:

Training in:

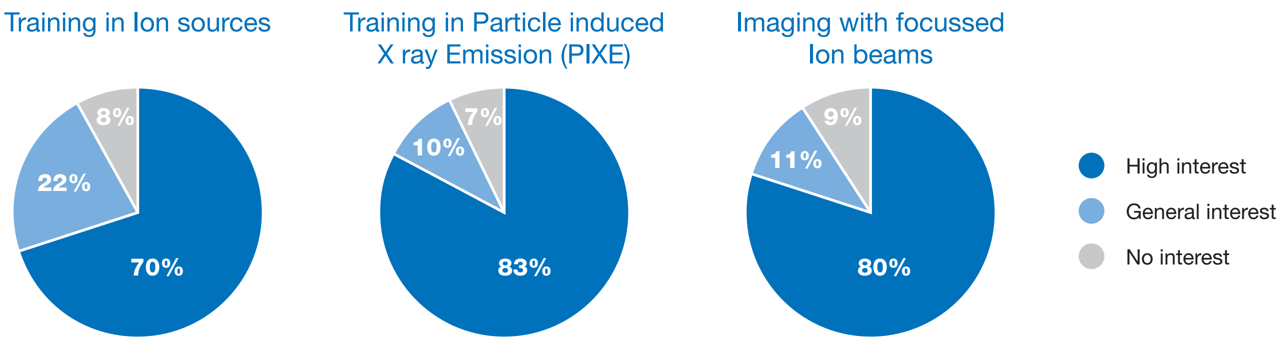
- Ion Beam Analysis (IBA) techniques;
- accelerator technology, such as ion sources and vacuum systems;
- end stations, such as design and assembly, radiation detectors, control systems and nuclear electronics.

Services relevant to:

- IBA for bulk analysis of air pollution, environmental and trace elements in reference materials;
- Nuclear microprobe applications, such as micro-PIXE, Rutherford Backscattering (RBS), Nuclear Reaction Analysis (NRA), particulate reference materials.

Applied research using:

- IBA for homogeneous bulk analysis of air quality, archaeological samples, minerals;
- 2&3D imaging and spatially resolved analysis using a microprobe.



Proposed ion beam accelerator options

The feasibility study showed that the two most cost-effective options are 1.7 MV and 3 MV Tandem accelerators. Both cover a broad range of MeV ion beam applications. 3 MV Tandem is more versatile and offers further applications as presented below.

Ion beam applications	Ion beam techniques	Proposed accelerator options	
		A: 1.7 MV Tandem (protons up to 3.4 MeV)	B: 3.0 MV Tandem (protons up to 6 MeV)
Capacity building through education and training	accelerator technology and ion-beam based techniques	Full	Full
Environmental monitoring – air and water quality – climate change studies	RBS, PIGE, PIXE, Micro-Focused Ion Beams	Full	Full
Geological elemental mapping, such as soil or sediment characterization	RBS, PIGE, PIXE, Micro-Focused Ion Beams	Full	Full
Analysis of biological samples – toxic element identification – medicine	PIXE, IBIL, Micro-Focused Ion Beams, NRA, MeV-SIMS	Full	Full
Analysis of structural materials for energy applications including fusion	RBS, PIGE, PIXE, NRA, IBIC, IBIL	Full	Full
Cultural heritage studies	RBS, PIGE, PIXE, Micro-Focused Ion Beams, external Micro-Focused Ion Beams	Full	Full
Neutron production complementary to other facilities at SEIB	via low energy p+Li reaction	Full	Full
Dosimetry and cancer research	high energy ion beam irradiations	Partial	Partial
Nuclear data for various fields of nuclear technology	all ion beam techniques	Partial	Partial
Multilayer analysis, depth profiling, 3D imaging of materials of technological interest	RBS, EBS, Micro-Focused Ion Beams, ToF-ERDA	Partial	Full
Materials modification and testing by irradiation of structural materials for energy applications, Si doping, irradiation of semi-conductors, space electronics, etc.	high energy proton and heavier ion beam irradiations and characterizations	Partial	Full
Surface analysis of materials of technological interest, e.g. photovoltaics	RBS, EBS, Micro-Focused Ion Beams, ToF-ERDA, MeV-SIMS, IBIC, IBIL	Partial	Full
Forensic studies: combination of different techniques applied to various domains	RBS, EBS, Micro-Focused Ion Beams, ToF-ERDA, MeV-SIMS	Partial	Full
Food quality and security – nutrition value	PIGE, PIXE, Micro-Focused Ion Beams, NRA	Partial	Full
Mutation breeding studies of seeds, plants, rice etc.	high energy proton and heavier ion beam irradiations	Limited	Partial

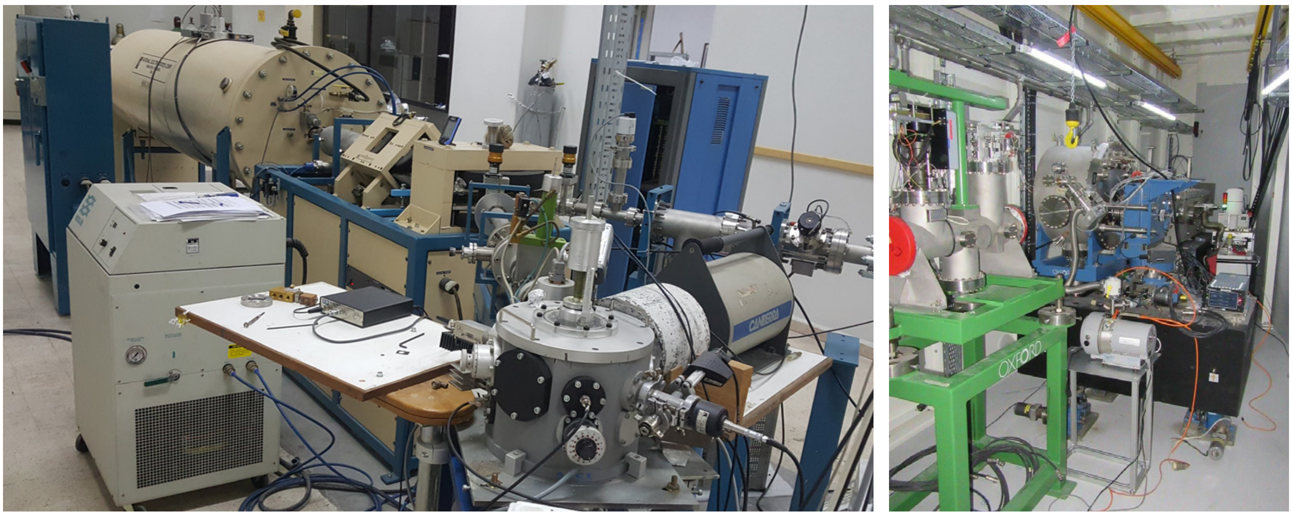
Full capability: applicable to all established techniques relevant to a given application, including those under development without any restrictions; fully compatible for capacity building.

Partial capability: applicable for most of the established techniques with some limitations due to lower energies; fully compatible for capacity building.

Limited capability: applicability either not possible or yet not fully established due to lower energies but could be explored for demonstration purposes and capacity building.

REQUIRED RESOURCES & INFRASTRUCTURE	OPTION A: **1.7 MV Tandem** (protons up to 3.4 MeV)	OPTION B: **3 MV Tandem** (protons up to 6 MeV)
Accelerator capital costs (includes standard ion sources)	1400 k€	2600 k€
Basic equipment for 2-3 beam lines	450 k€	450 k€
Combination of 3 end stations	400 k€	400 k€
Instrumentation of X-ray and particle detection, data acquisition, software etc.	250 k€	250 k€
Supplier with track record	Yes	Yes
TOTAL investment costs for equipment (turn key scenario)	**2500 k€**	**3700 k€**
Minimum number of staff required	3	4-5
Minimum space required	200 m^2	400 m^2
Heavy shielding required	No	Yes
New building required	No* / Yes	
TOTAL investment costs for buildings and additional infrastructure	**from 300 k€ (for refurbishing)* to 800 k€ (if new building)**	
Annual operating and maintenance costs (excluding salaries)	~100k€	~150k€

* When using an existing building in Seibersdorf.



Typical example of a 1.7 MV tandem accelerator facility

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