IAEA
International Atomic Energy Agency
Atoms for Peace and Development

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

Sotirios Charisopoulos

Natko Skukan

Kalliopi Kanaki

Danas Ridikas

International Atomic Energy Agency - IAEA
Dept. of Nuclear Science and Applications,
NAPC/Physics Section

IAEA: An autonomous international organization within the United Nations system

173 Member States; 2500+ staff from over 100 Member States; HQ in Vienna

- Labs in Seibersdorf, Vienna and Monaco
- Regional offices in Toronto and Tokyo; Liaison offices in New York and Geneva

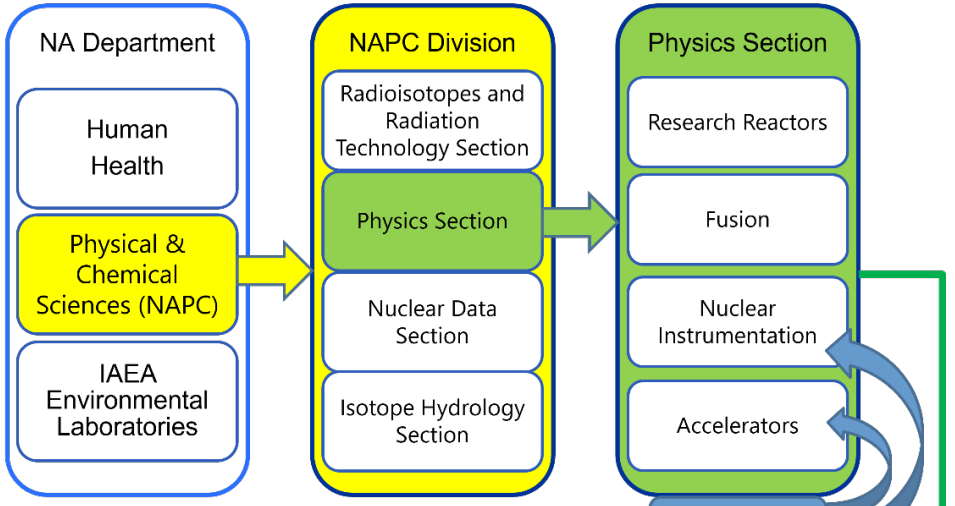
Mission: to serve the Member States

The IAEA

- assist its Member States, in planning & using nuclear science & technology for peaceful purposes
- facilitate transfer of knowledge in a sustainable manner to developing Member States
- develop nuclear safety standards and promote high levels of safety in applications of nuclear energy, and the protection of human health and the environment against ionizing radiation;
- verify through its inspection system that States comply with their commitments to use nuclear material and facilities only for peaceful purposes.

Structure

The Department of Nuclear Science and Applications (NA)



- Staff: 21 positions, 11@HQ & 10@Seibersdorf,
- + consultants, interns, fellows; TOTAL: ~30-35
- Budget: ~4M Euros RB under 4 sub-programmes

Relevance to the SDGs

The IAEA laboratories

Water Resources

Food & Agriculture

Human Health

Nuclear Science

1. **Insect Pest Control**
2. **Animal Production & Health**
3. **Plant Breeding & Genetics**
4. **Soil and Water Management & Crop Nutrition**
5. **Food Safety and Control**
6. **Dosimetry Laboratory**
7. **Terrestrial Environment**
8. **Nuclear Science and Instrumentation**

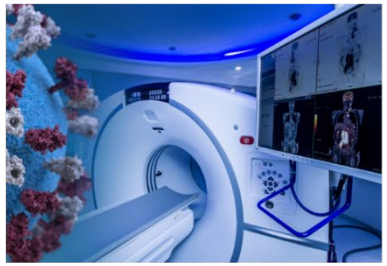
Marine Environment

Areas of work and Capacity Building methodology

sustainable agricultural development

food security and nutrition

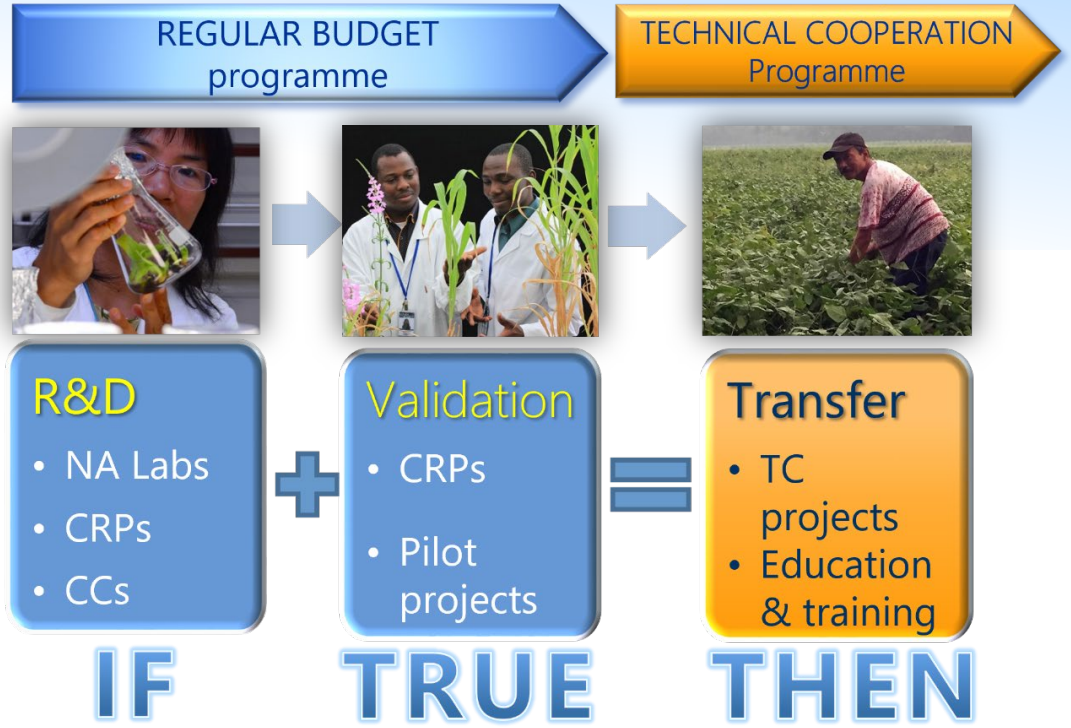
cancer diagnosis and treatment modalities



cleaner water for more people

protecting the environment

Providing expertise for industrial applications



Key Principles for TC Projects

- Contribute to development goals
- Respond to Member States' needs
- Undertake peaceful use of nuclear technology
- Comply to IAEA safety and security rules
- Ensure Member State ownership & shared responsibility
- Ensure non-discrimination of stakeholders

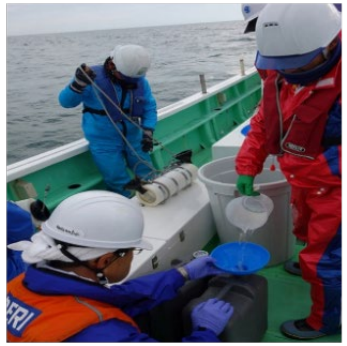
The IAEA Technical Cooperation Programme

Primary mechanism for transferring nuclear technology to Member States, implemented through National, Regional or Interregional TC Projects

- Capacity building
- Networking
- Knowledge sharing
- Partnership building

Fellowships
Scientific visits

Expert assistance



Equipment & materials

Conferences, Symposia

Training courses & workshops

The SESAME Interregional TC Project (2010-2023; ≈2M€)

(SESAME was inaugurated on May 16, 2017, in Jordan)

Over the last decade IAEA has provided extensive support to train staff at SESAME to commission and run the facility. This has included instruments, the training of 66 technical and scientific fellows in beamline technologies, and over 30 expert missions to SESAME to help build capacity in the installation and testing of equipment.

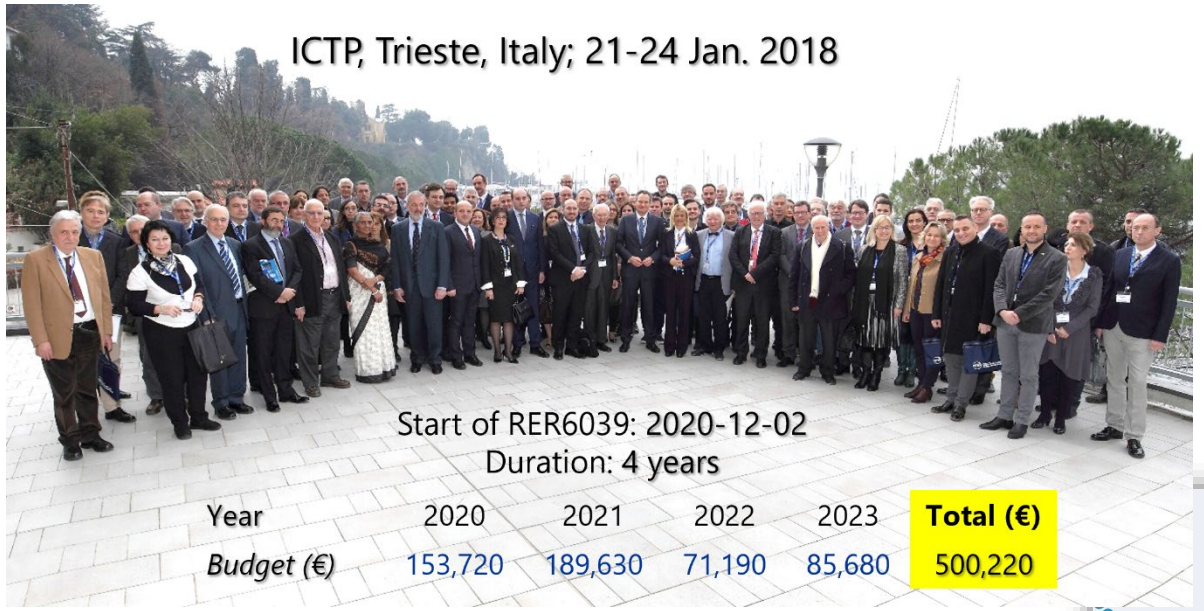
IAEA also facilitated the networking of SESAME staff with experts from other synchrotron facilities in Europe, the United States and Japan.

In 2018, Training Workshop held in SESAME, Jordan, with remote connection to Elettra

New Interregional TC project in preparation: Expansion of network across all continents.

The RER6039 Regional TC Project (SEEIIST)

"Developing Human Resources for Setting Up an Ion Beam Therapy Centre within the Joint South East European International Institute for Sustainable Technologies"



Year	2020	2021	2022	2023	Total (€)
Budget (€)	153,720	189,630	71,190	85,680	500,220

Decisions on

- Overall Workplan of TC project
- Capacity building through scientific visits
- Training program (3 Fellowships)
- Next workshops

Training at CNAO (Pavia, Italy) in 5 different topics for 12 months

1. Study of Slow Beam Extraction
2. Characterization of a new acquisition system for the Schottky Monitor of the CNAO Synchrotron
3. Development of a monitor for low intensity beams.
4. Development and test of electronics boards
5. Control system development.

Development Objective:

To build critical mass of human resources initially needed for the merits of the emerging hadron tumour therapy and research facility – SEEIIST.

UZB006: A national TC project

objective — To improve and develop educational processes in nuclear science and applications of nuclear techniques and methods in the economic sector of the Republic of Uzbekistan

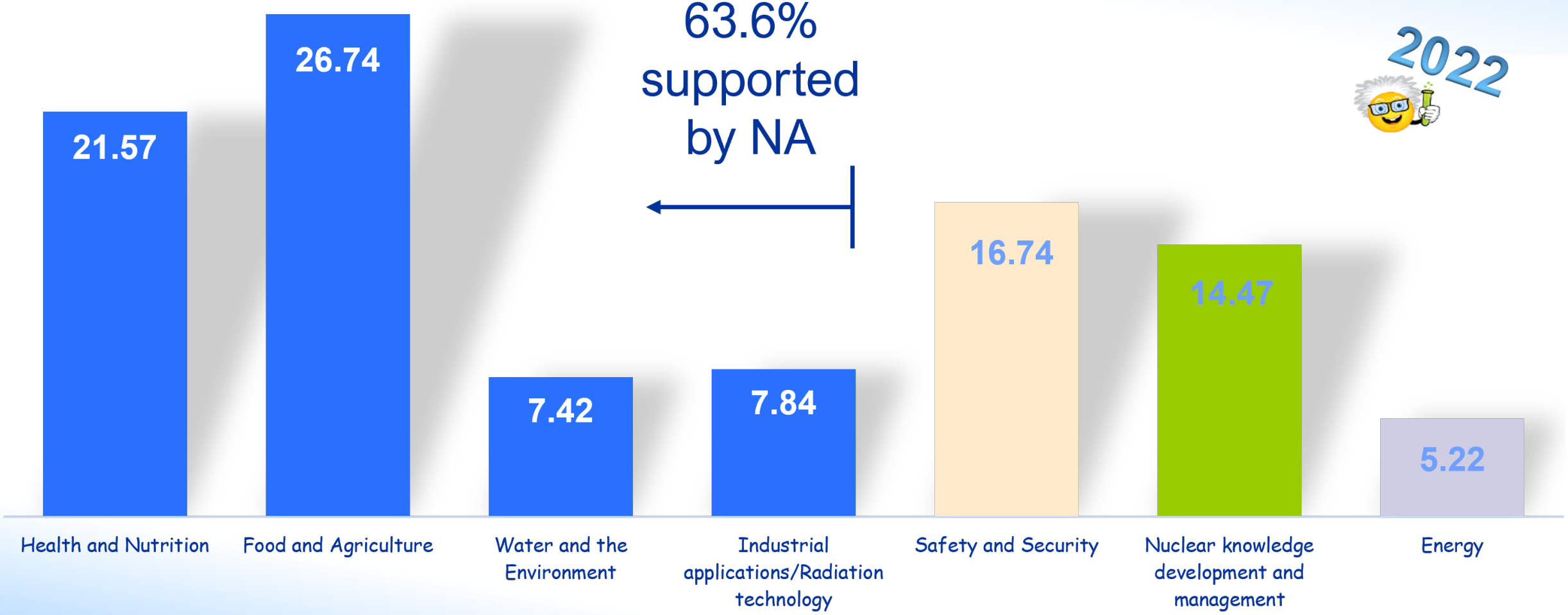
outcome — Academic programmes in the field of nuclear science and technologies established at the National University of Uzbekistan (Tashkent) and the Samarkand State University;
=>new lab courses in nuclear spectroscopy, nuclear electronics, accelerator and reactor physics

activities — 6x fellowships (up to 6 months) – 2x scientific visits – 4 expert missions
Procurement of new scientific instruments and analysis software

Similar projects: Cambodia, Botswana, Laos …

Disbursement at Country Level through IAEA Technical Cooperation Programme

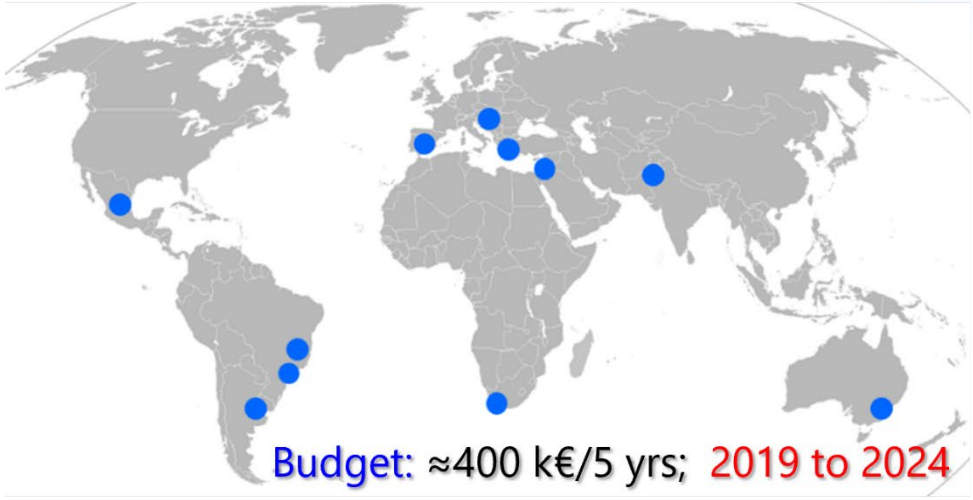
Source: Technical Cooperation Report 2022



The tools

- Consultancy Meetings: 5 to 10 experts are invited to provide specialized advice and recommendations on particular scientific or other aspects of relevance for the IAEA's programmes and activities.
- Technical Meetings: Technical events with 30-40 participants, aiming at enhancing interaction among experts, share knowledge and expertise, establish scientific collaborations and create topical networks.
- Coordinated Research Projects (CRPs): Networks of 10-15 research institutes from developed and developing countries that work in coordination for 3-5 years to acquire and disseminate new knowledge/technology. Periodic meetings are organized to report progress and plan/coordinate future activities.
- Training Workshops, Courses and dedicated Schools: Events enabling participants to acquire specific knowledge on a given subject of interest. Organized at IAEA labs, ICTP Trieste, or at labs in member states
- Publications of technical documents and guides: Publications of reported results, shared good practices and lessons learned; produced by CRPs or Technical Meetings.
- Collaborating Centres: IAEA Member State institutions/organizations are designated as *IAEA Collaborating Centres (CC)* to cooperate in the implementation of selected programmatic activities of the Agency.
- National, regional, interregional Technical Cooperation (TC) projects: projects to build capacity via Expert Missions, training of personnel, purchase of equipment, assistance in establishing new facilities, …

G42008: A CRP facilitating experiments with Ion Beam Accelerators



- Transnational access to IBA facilities across the world for researchers without local access to an accelerator
- Currently, 11 accelerator laboratories distributed in different geographical areas, where potential users are most expected
- Travel grants to external non-local users after submission and successful evaluation of a research proposal to/by the IAEA and acceptance by the host laboratory.
- some support to beam providing labs for consumables

The launch of this CRP was recommended by experts in a Consultancy Meeting (March 2018)

IBA/Nuclear Techniques covered

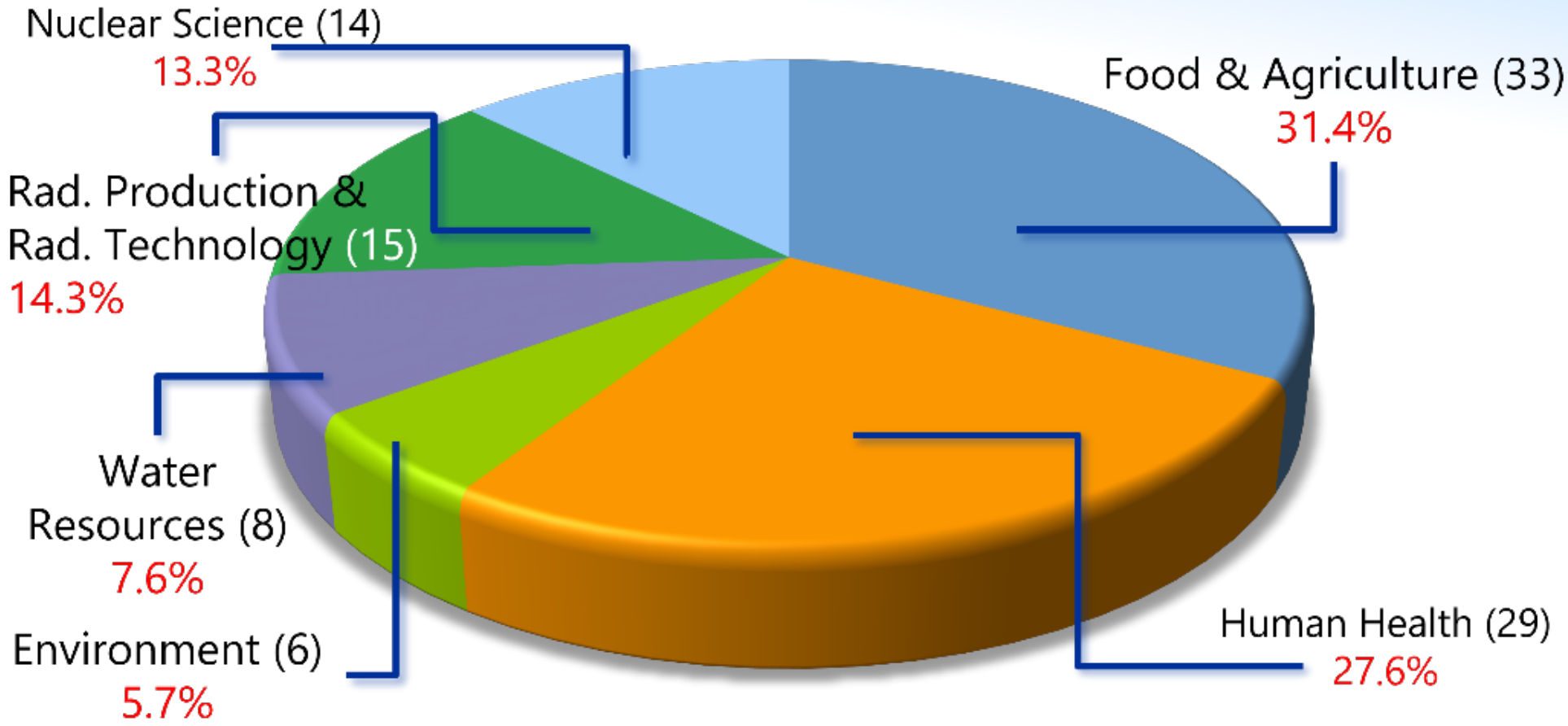
- PIXE/PIGE
- μ-PIXE
- RBS, Channelling
- NRA
- (ToF)-ERDA,
- MeV SIMS,
- AMS
- Nuclear reaction studies

So far

19 experiments completed/planned

- Biology (2)
- Ecology (6)
- Geology (1)
- Agriculture (3)
- Archaeology (2)
- Materials science (4)
- IBA/Nuclear physics (1)

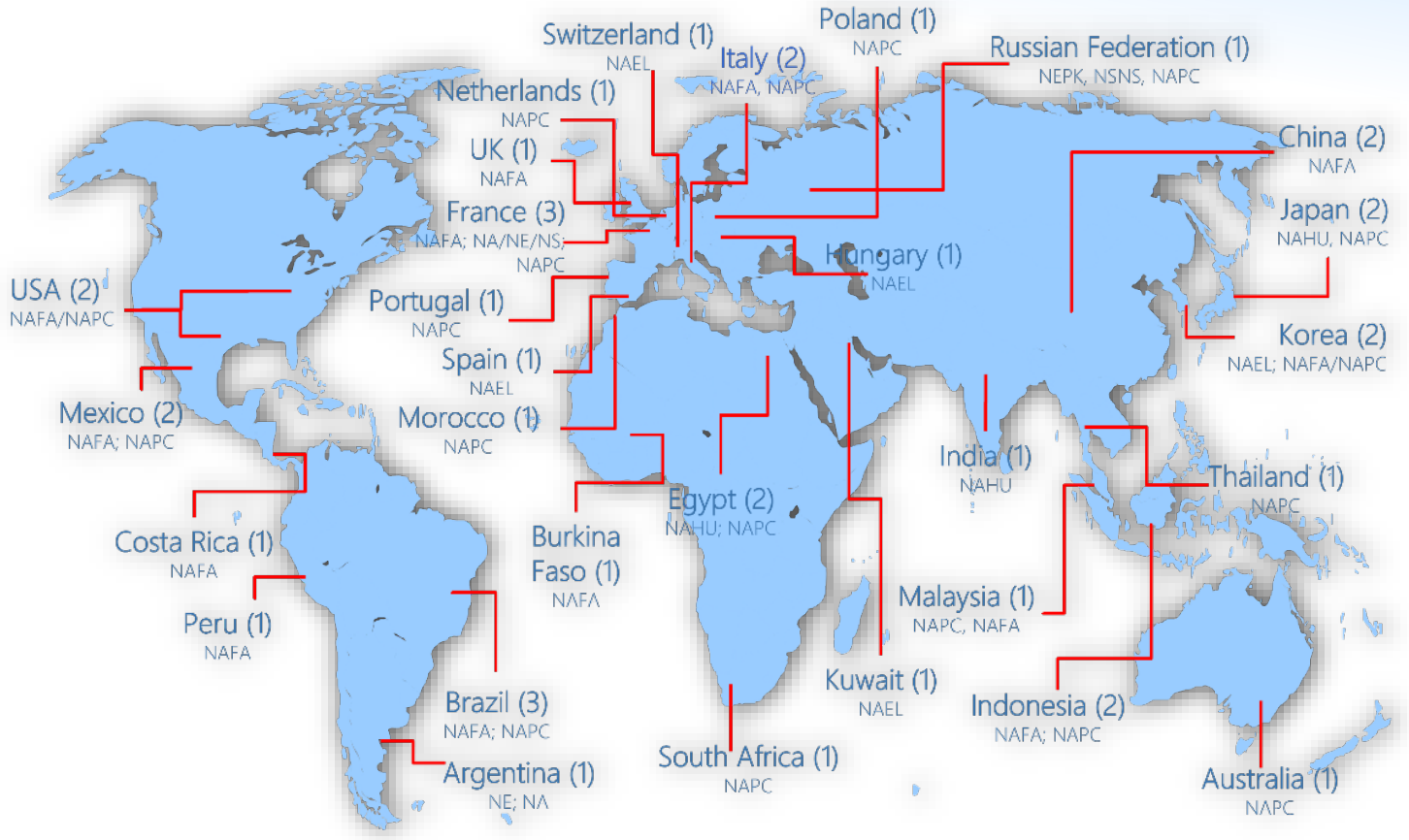
Coordinated Research Projects – NA Department (2022)



NACA, 2022 data

IAEA Collaborating Centres

IAEA Member State institutions organizations are designated as *IAEA Collaborating Centres* to cooperate in the implementation of selected programmatic activities of the Agency.



The designation process takes effect with the signing of an Agreement between the IAEA and the CC organization.

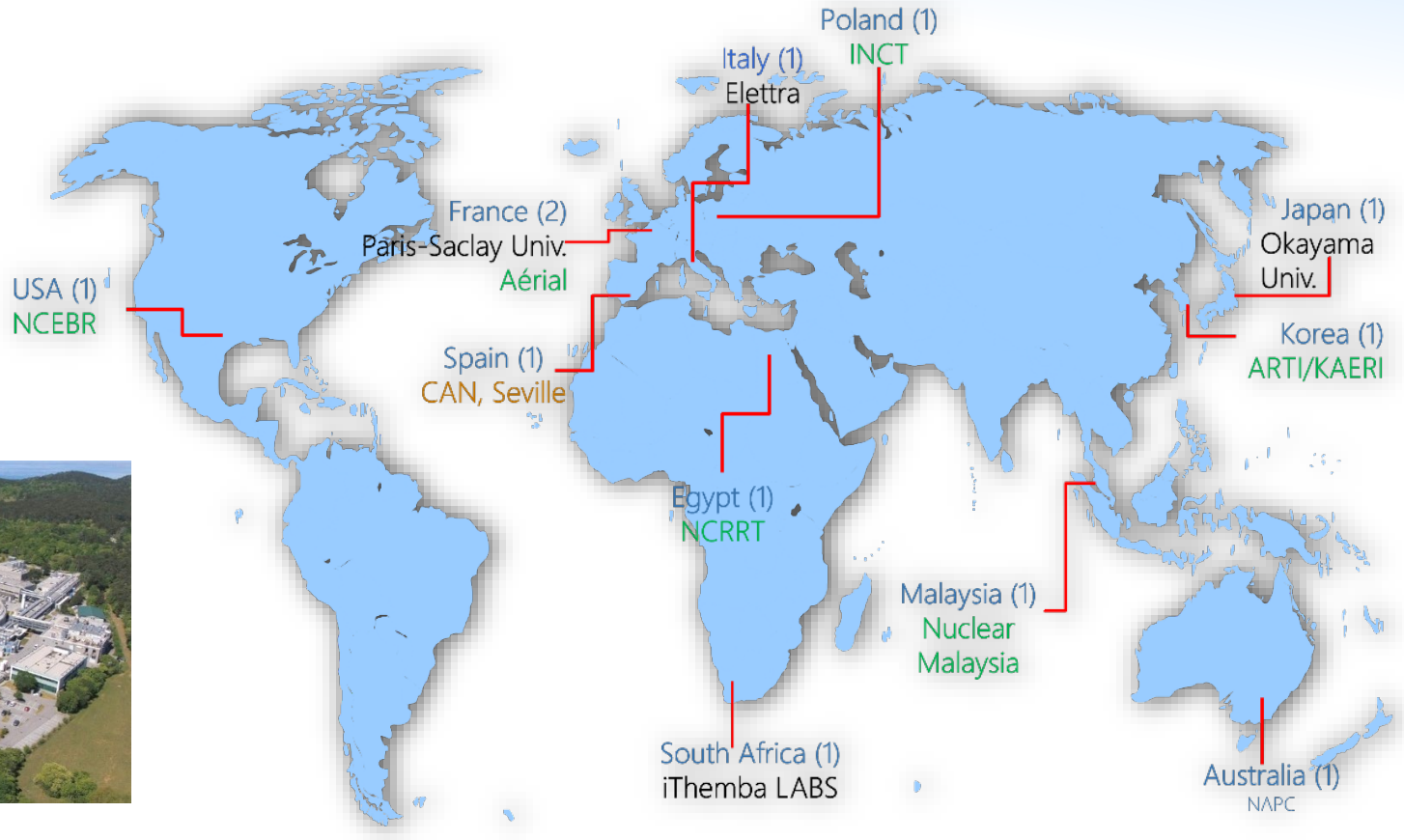
This is a legally binding document defining the cooperative undertakings, duration of designation, objectives, activities, and expected results and outcomes stated in a jointly agreed Work Plan, which addresses R&D work, educational and training activities and, in many cases, cost-free services to the IAEA and its Member States.

IAEA Collaborating Centres

Elettra Sincrotrone, Trieste, Italy

Synchrotron applications and technologies

Support the IAEA in the implementation of activities in the IAEA Programme "Nuclear Techniques for Development and Environmental Protection"



Signing ceremony, 9 Nov. 2021

Work plan

- Assistance to developing MSs intending to build synchrotron facilities including training of their scientists & technologists in light sources design and beamline design control systems & detectors.
- Assistance to developing MSs in implementing new methodologies for expanding the application fields of synchrotron and FEL techniques.

Technical Meating: Advanced methodologies for the analysis of materials in energy application using Ion Beam Accelerators (8–11 Oct. 2018, Vienna)

new CRP (10 facilities, 10 countries, 34 scientists)

Objectives

- Identify data needs and measure fundamental cross-sections for nuclear reactions with fusion relevant materials
- Identify data needs and measure stopping powers in fusion relevant materials with Helium ions
- Define international standards for the analysis of fusion-relevant materials
- Define and produce reference samples for Round-Robin tests in the IBA fusion community

2021 - 2023

Phase 1

- Cross section measurements
- Stopping power measurements
- Preparation or provision of reference samples for the development of good practices & standardization of measurements
- Conducting experiments with reference samples for the development of good practices & standardization of measurements
- Evaluation of analysis software for the development of good practices & standardization of measurements
- Round robin test with pre-characterized reference samples

2023 - 2025

Phase 2

- Analysis and inter-comparison of
  - cross-section measurements
  - stopping power measurements
  - Round Robin results
- Analysis of results from experiments for the standardization of the IBA techniques
- Drafting a TECDOC on international good practices and procedures for IBA techniques

joint publication (review)

IOP Publishing | International Atomic Energy Agency — Nuclear Fusion
Nucl. Fusion 60 (2020) 025001 (20pp) — https://doi.org/10.1088/1741-4326/ab5817

Special Topic

M. Mayer *et al.*, Nuclear Fusion 60, 025001 (2020), Special topic (review paper)

Ion beam analysis of fusion plasma-facing materials and components: facilities and research challenges

M. Mayer[1], S. Möller[2], M. Rubel[3], A. Widdowson[4], S. Charisopoulos[5], T. Ahlgren[6], E. Alves[7], G. Apostolopoulos[8], N.P. Barradas[5], S. Donnelly[9], S. Fazinić[10], K. Heinola[5], O. Kakuee[11], H. Khodja[12], A. Kimura[13], A. Lagoyannis[14], M. Li[15], S. Markelj[16], M. Mudrinic[17], P. Petersson[3], I. Portnykh[18], D. Primetzhofer[19], P. Reichart[20], D. Ridikas[5], T. Silva[21], S.M. Gonzalez de Vicente[5] and Y.Q. Wang[22]

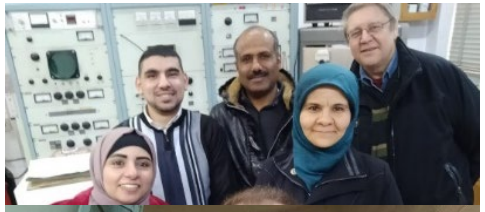
Disseminating expertise in accelerator technologies

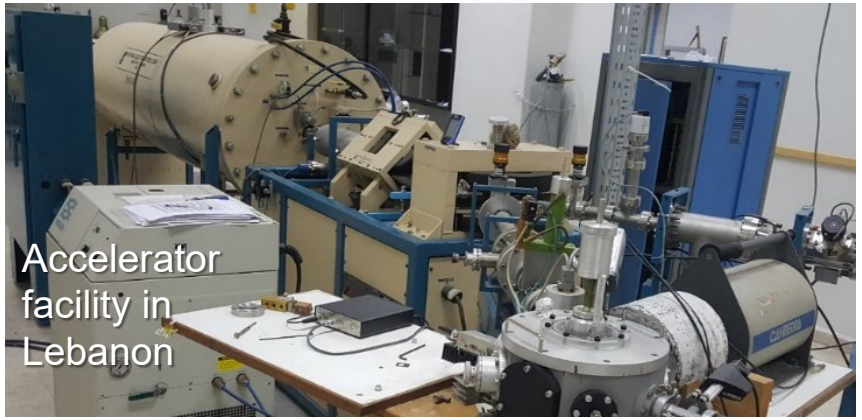
The IAEA Physics Section:

- facilitates hands-on training of scientific and technical personnel in accelerator operation and maintenance
- assists in refurbishment and modernization of beam lines and associated instrumentation
- assists in feasibility and design studies and the preparation of business and strategy plans
- provides technical support in specifications, procurement, installation, repairs & upgrades of exp. devices.

in collaboration with TC Dept.

- Algeria
- Egypt
- Ghana
- Nigeria
- South Africa
- Bangladesh
- Croatia
- Jordan
- Lebanon
- Mexico
- Slovakia
- Syria
- Thailand





Support in procurement of the 1.7MV Pelletron accelerator; technical assistance in starting up the laboratory and the development of a new beamline for a nuclear microprobe; additional upgrades of the accelerator & setups; training of staff in accelerator technology and ion beam analysis.

Training young scientists and accelerator operators

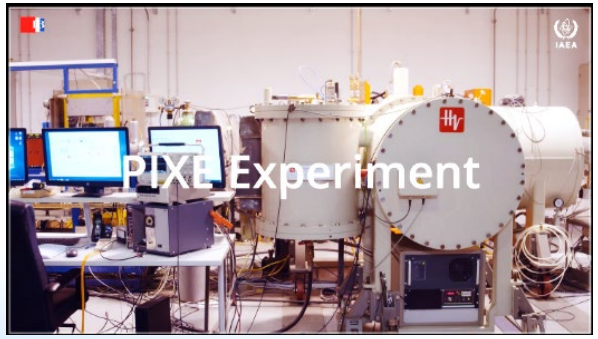
Training Workshop: *Hands-on Operation & Maintenance of Electrostatic Accelerators; RBI, Zagreb, 9-13 Dec. 2019*

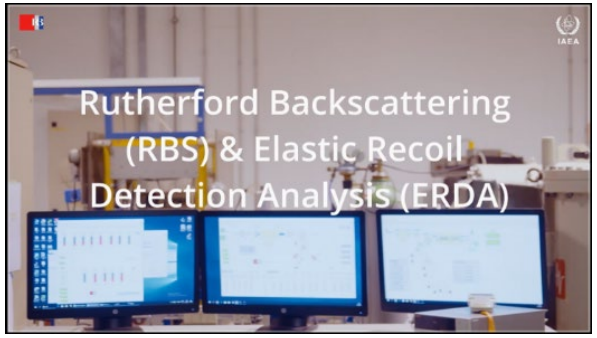
- ✓ Accelerator controls, control software, voltage measurements and stabilization, Dew point measurements, Magnetic hysteresis evaluation, Terminal voltage calibration.
- ✓ Vacuum systems: setting up & measurements, leak detection, RF&DC discharges in gases.
- ✓ Ion sources: beam extraction, beam current measurements, changing source parameters, element selection & optimization, changing Duoplasmatron operation
- ✓ Beam optics: Basic theory, beam focusing & steering, quadrupole alignment, beam brightness & size measurements.

Repeated: iThemba LABS, J'burg, SAF, Dec. 2022, & RBI, Zagreb, Croatia, Oct. 2023

Training Workshop: *Advances in Ion Beam Techniques & Applications (Virtual), RBI, Zagreb, Croatia, 1-5 March 2021*

Intro-lecture (60-90 min) – Demo video (≈20 min.) – Discussion/Questions/Exercises (90 min) – Homework (data analysis)
36 trainees (10 from Africa) – [17 female] – 16 Member States





https://nucleus.iaea.org/sites/accelerators/Pages/IBA-video-demonstrations.aspx

Repeated: RBI, Zagreb, Croatia, Nov. 2022; Planned: RBI, Zagreb, Croatia, Dec. 2024 & CNEA, Bariloche, Argentina, April 2025

Training young scientists and accelerator operators

Joint ICTP-IAEA Workshop on Electrostatic Accelerator Technologies, Basic Instruments and Analytical Techniques 2019

21 - 29 October 2019
Trieste, Italy

Further information:
http://indico.ictp.it/event/8728/

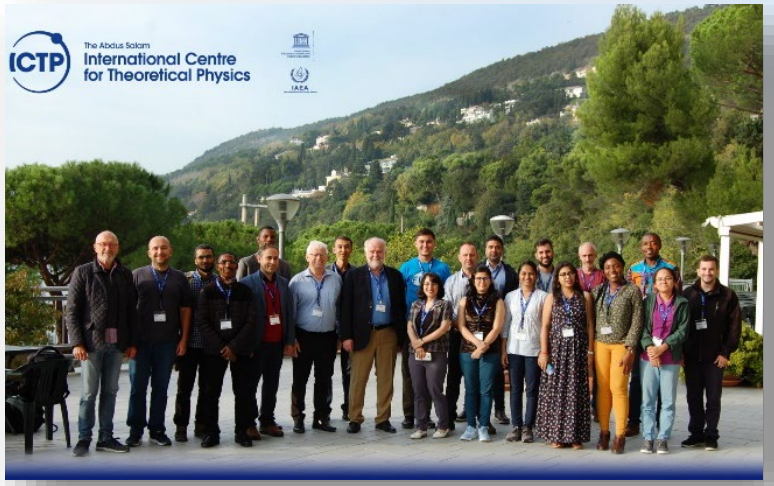
Topics

- Introduction to electrostatic accelerators and their operation
- Ion sources and vacuum systems at electrostatic accelerators
- Ion-beam optics, beam focusing, and monitoring devices
- Introduction to low energy nuclear reactions
- Ion-beam analytical techniques
- Selected ion-beam based applications
- Modern detector technologies
- Basic software for data analysis and accelerator control

IAEA International Atomic Energy Agency

ICTP The Abdus Salam International Centre for Theoretical Physics

http://indico.ictp.it/event/8728/



7 Lecturers

(22 lectures; 4 hrs excercises on PC)

17 Trainees <age>=33; 1/3 females

Argentina (1), Cameroon (1), Egypt (1), Ghana (1), Greece (1), India (3), Iran (2), Lebanon (1), Nepal (1), Senegal (1), South Africa (1), Ukraine (1), Uzbekistan (2)

2 Lab visits (full day)

- Laboratori Nazionali di Legnaro, Italy
- Jozef Stefan Institute, Ljubljana, Croatia

Training young scientists and accelerator operators

Topics

- Introduction to electrostatic accelerators and their operation
- Ion sources and vacuum systems at electrostatic accelerators
- Ion-beam optics, beam focusing, and monitoring devices
- Introduction to low energy nuclear reactions
- Ion-beam analytical techniques
- Selected ion-beam based applications
- Modern detector technologies
- Basic software for data analysis and accelerator control

IAEA International Atomic Energy Agency

ICTP The Abdus Salam International Centre for Theoretical Physics

http://indico.ictp.it/event/8728/

7 Lecturers

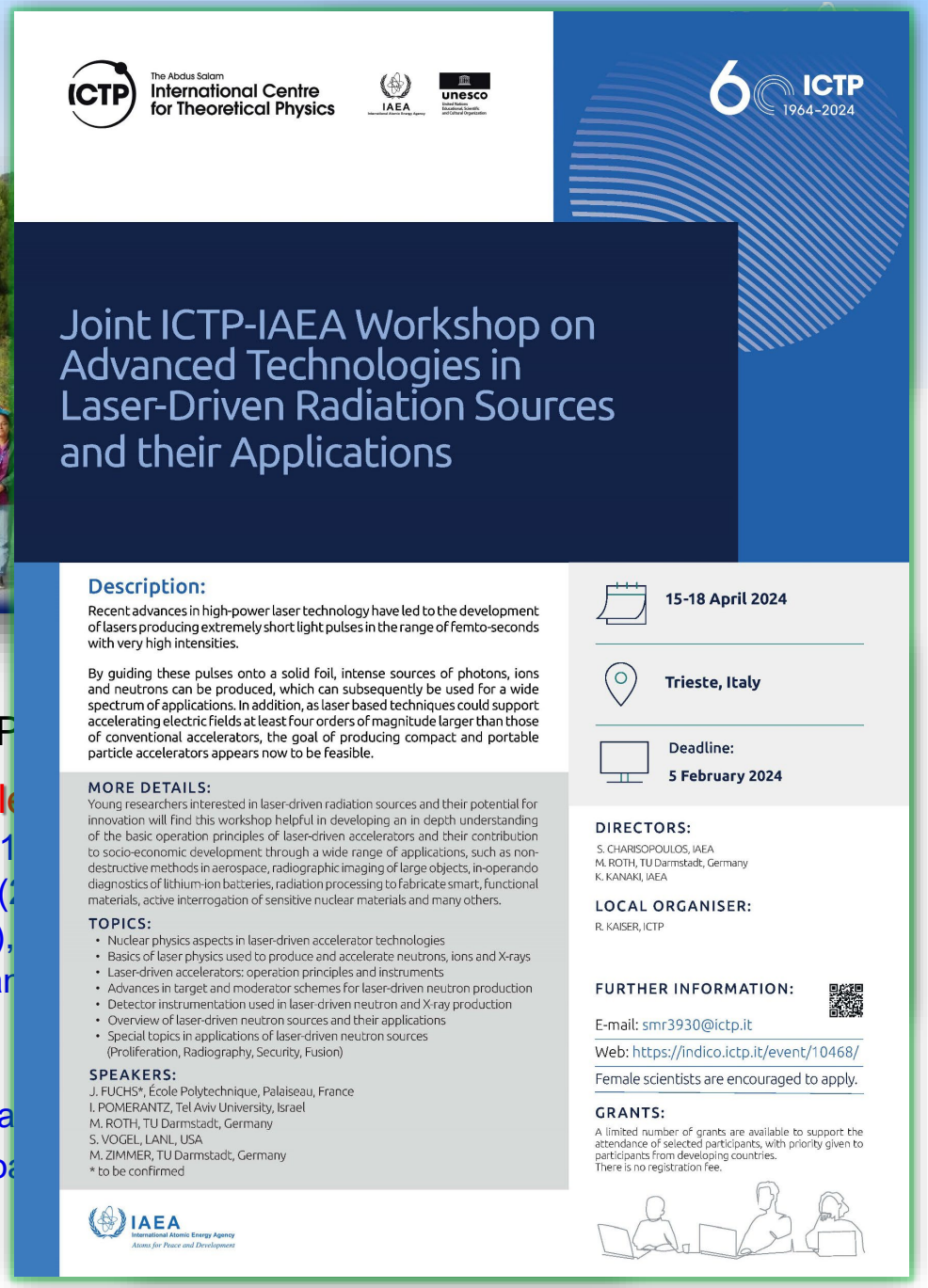
(22 lectures; 4 hrs excercises on P

17 Trainees <age>=33; 1/3 female

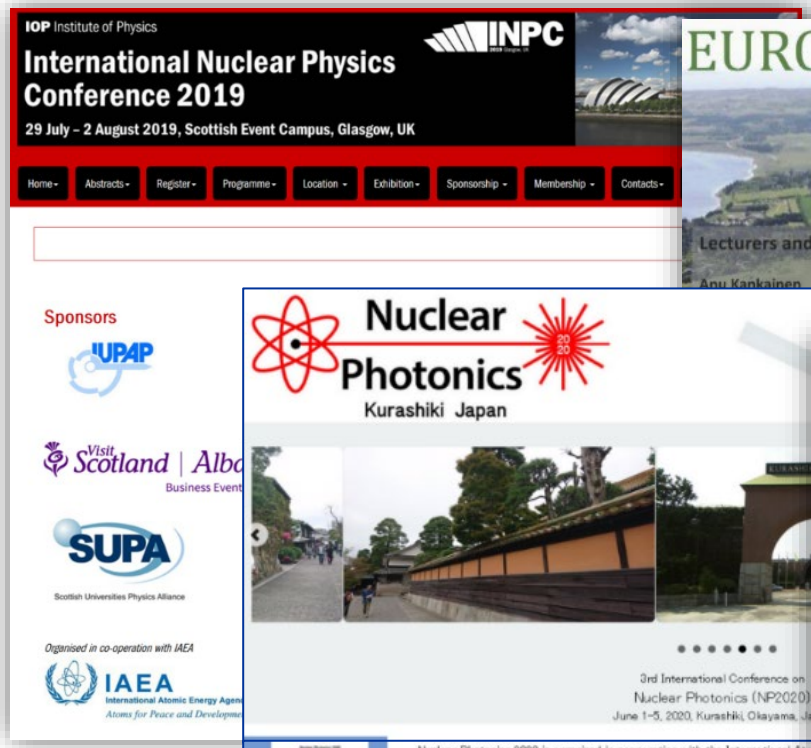
Argentina (1), Cameroon (1), Egypt (1
Ghana (1), Greece (1), India (3), Iran (2
Lebanon (1), Nepal (1), Senegal (1),
South Africa (1), Ukraine (1), Uzbekistan

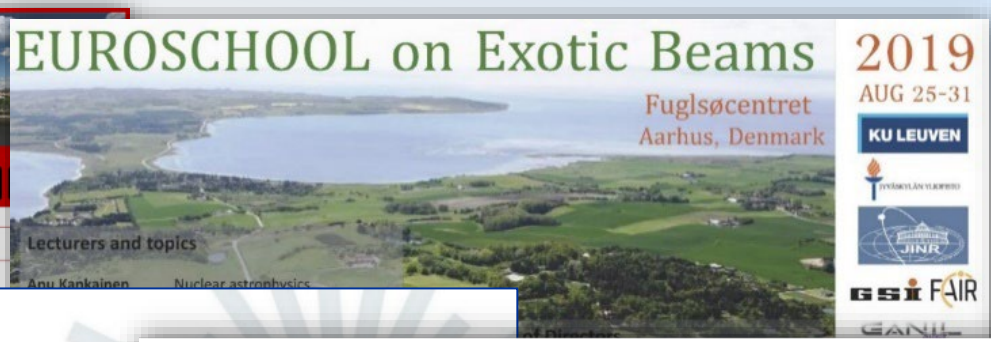
2 Lab visits (full day)

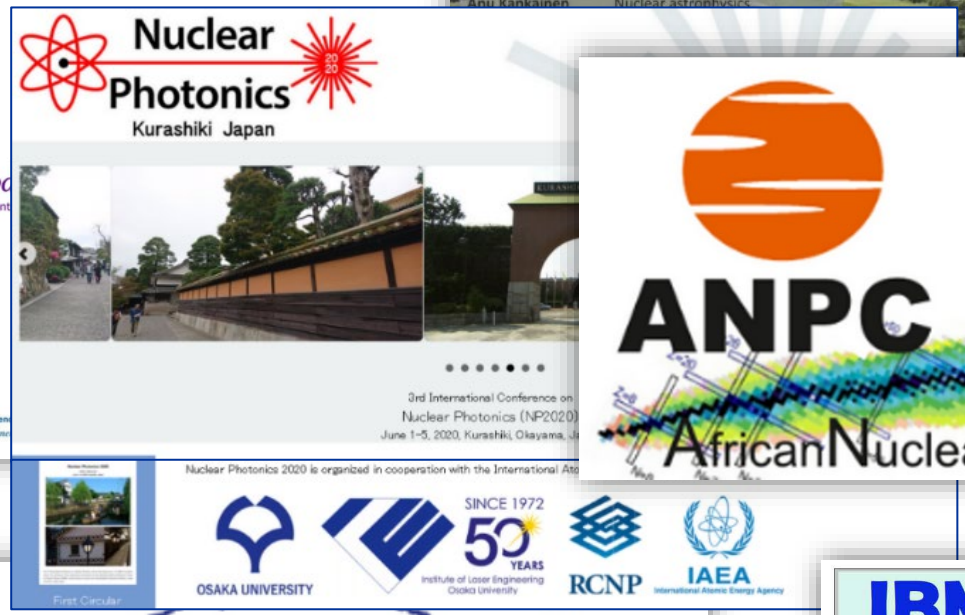
- Laboratori Nazionali di Legnaro, Ita
- Jozef Stefan Institute, Ljubljana, Croa

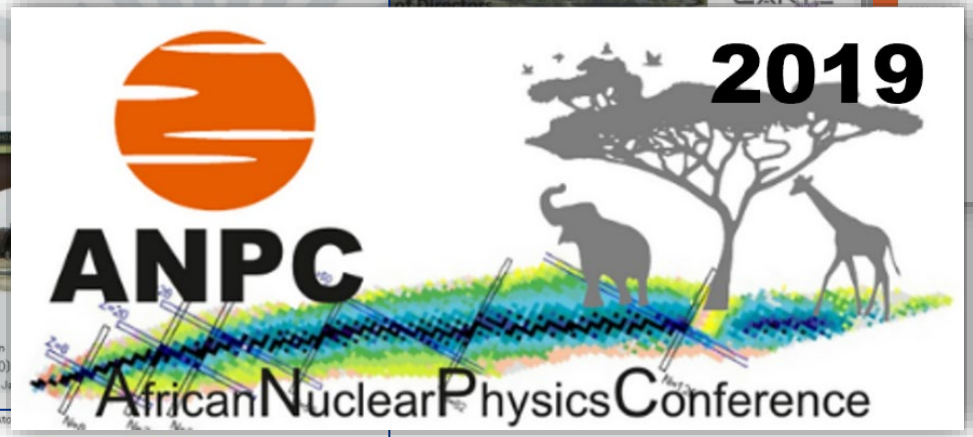


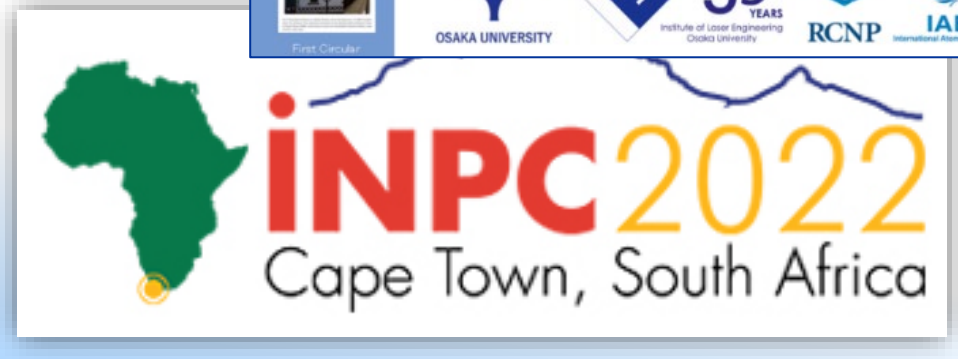
Scientific events in cooperation with the IAEA







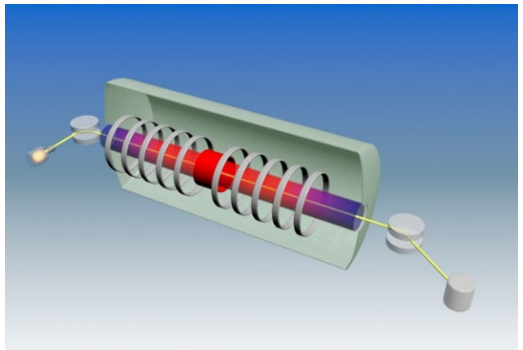




e-learning and publication of technical documents and report series

IAEA Learning Management System
powered by CLP4NET

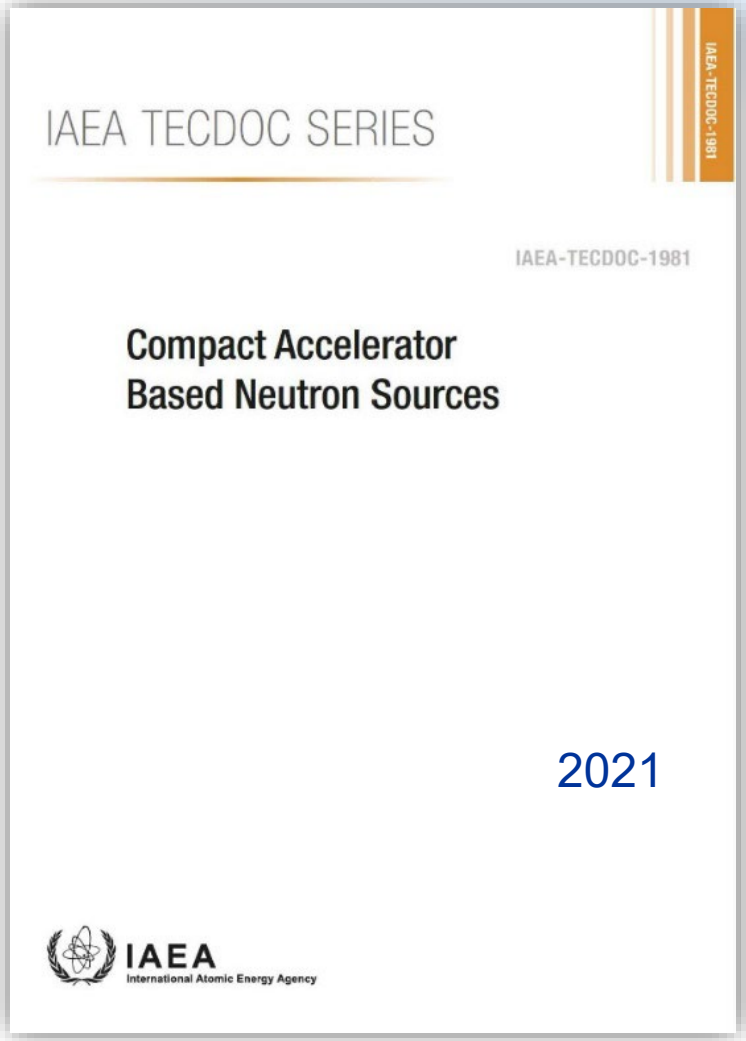
https://elearning.iaea.org/m2/course/view.php?id=761



Introduction to electrostatic accelerators: from basic principles to operation and maintenance

The electrostatic accelerator
Ion sources
Beam transport
Vacuum
Safety considerations

recommended for students, laboratory staff and users of these facilities

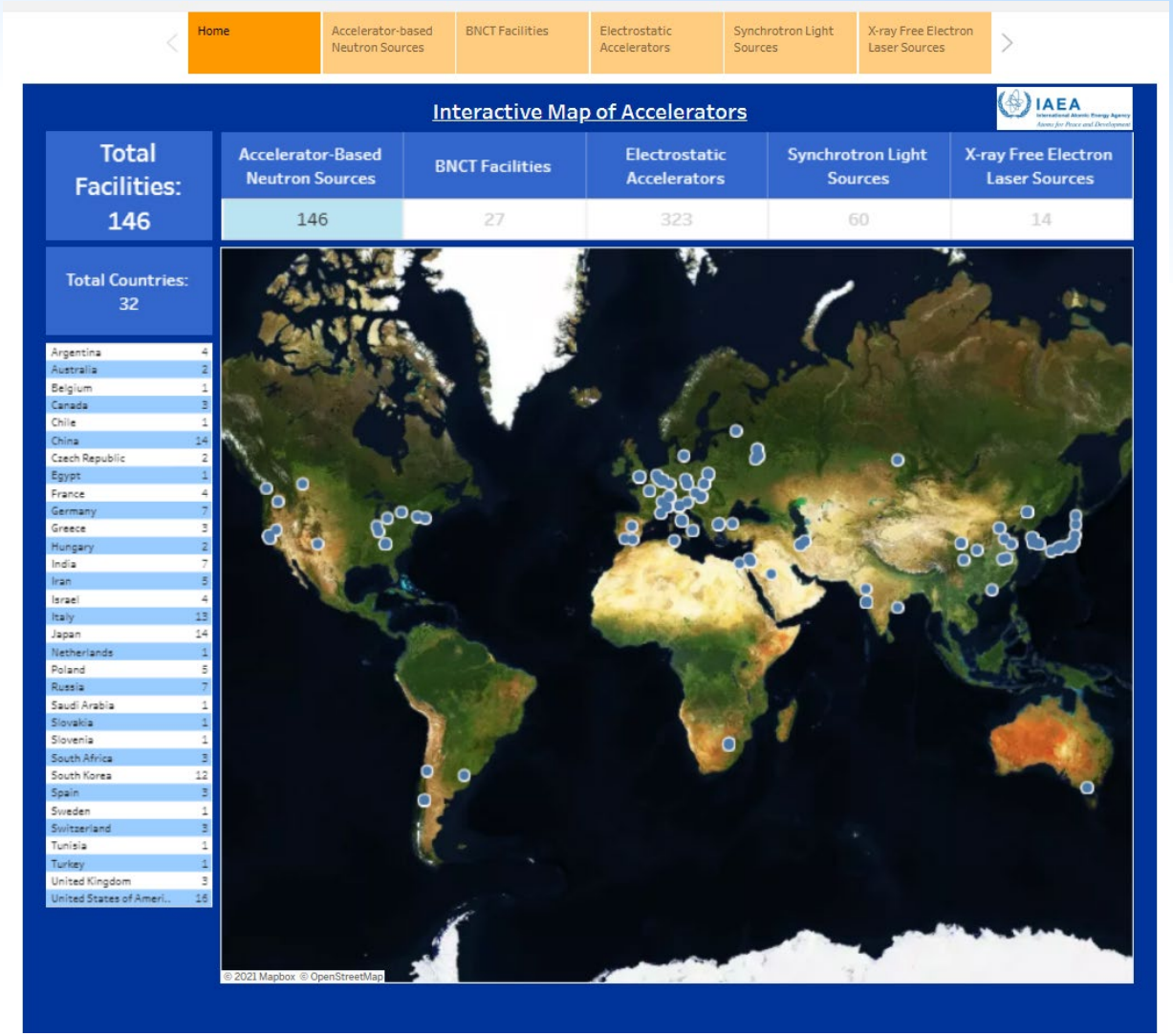


Management of databases and thematic portals

- Accelerators: https://nucleus.iaea.org/sites/accelerators/
- Research reactors: https://nucleus.iaea.org/RRDB/
- Fusion: https://nucleus.iaea.org/sites/fusionportal/
- Nuclear Instrumentation: https://nucleus-new.iaea.org/sites/nuclear-instrumentation/

Accelerator Knowledge Portal

- 3135 visitors/users in 2018
- ≈1700 accelerator-based facilities
- New entries: 1270 med. cyclotrons and 91 AMS facilities
- Planned to add proton/hadron therapy facilities and RIB facilities
- Includes case studies with Neutron and Ion Beam techniques



Interactive maps of accelerators and other facilities
https://nucleus.iaea.org/sites/accelerators/

The Ion Beam Facility (IBF) project

Motivated by a 2018-recommendation by SAGNE, the IAEA's Standing Advisory Group for Nuclear Energy to perform a comprehensive feasibility study for an ion beam accelerator facility, for nuclear capacity building and studies related to radiation damage, material science, environmental studies, etc. This study should provide options in terms of scope, capital and operational costs of the facility for decision making.

Through the performed feasibility study, it was assessed whether and how an ion beam accelerator at Seibersdorf could match the NSIL's mission and existing program of teaching and training, and the provision of services across many fields of relevance to the IAEA Member States and internal to IAEA users. For this purpose, a Stakeholder analysis and quantification of user needs was conducted.

Internal-to-IAEA stakeholders have contributed to the study through interviews and external stakeholders through a questionnaire. More than 60 replies were by 40 Member States indicating the most commonly demanded topics

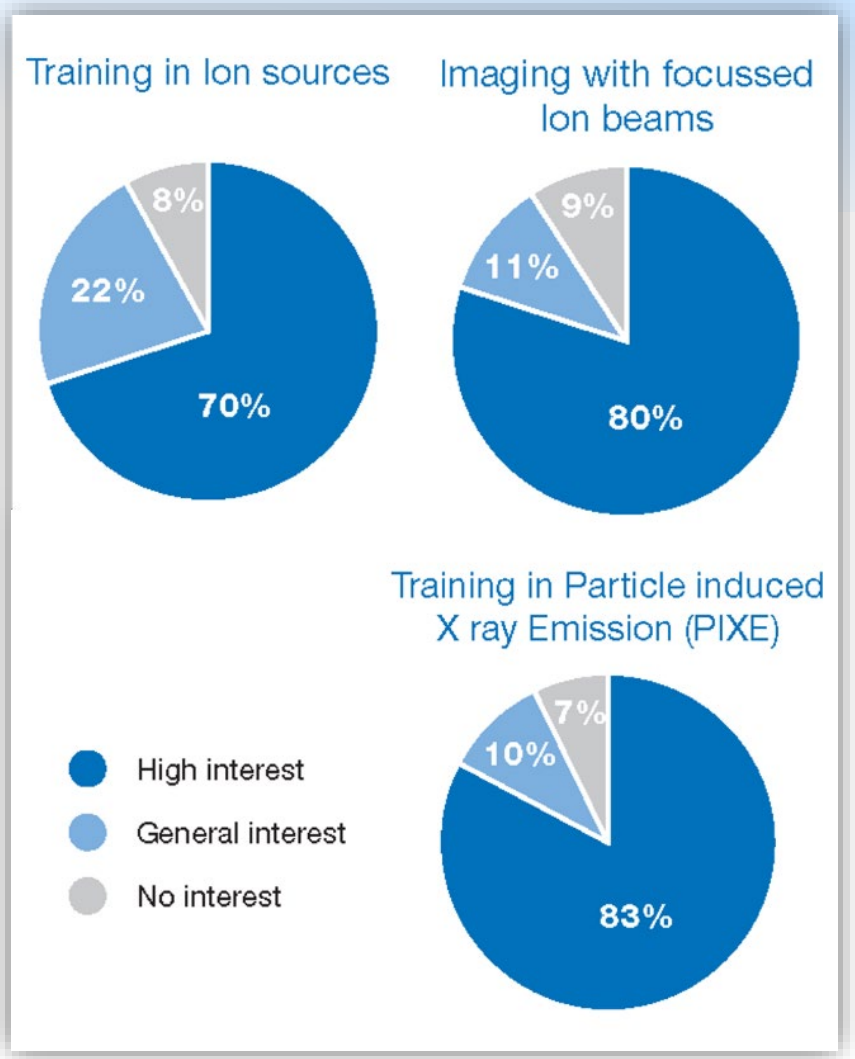
The Ion Beam Facility (IBF) project

IAEA

Stakeholder analysis and quantification of user needs

The most commonly demanded topics:

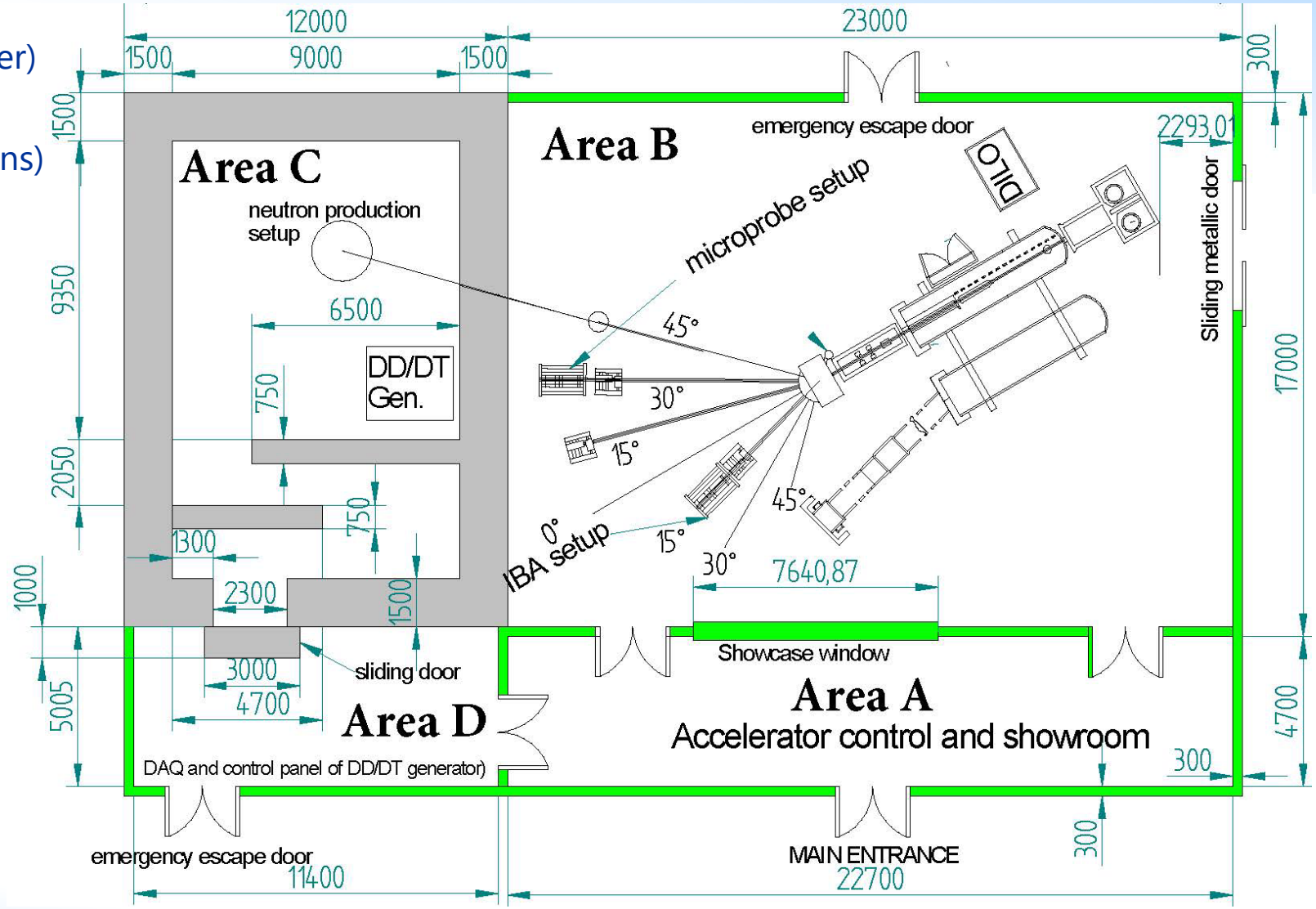
- **Training in:**
  - Accelerator technology such as ion sources and vacuum systems
  - End stations: design & assembly;
  - Radiation detectors; control systems & nuclear electronics
  - Ion Beam Analysis (IBA) techniques:
- **Services relevant to:**
  - IBA for bulk analysis of air pollution, environmental studies, etc.
  - Nuclear Microprobe: micro-PIXE, RBS, NRA; particulate reference materials
- **Applied research using:**
  - IBA for bulk analysis of air quality, archaeological samples, minerals
  - 2&3D imaging and spatially resolved analysis using a microprobe.



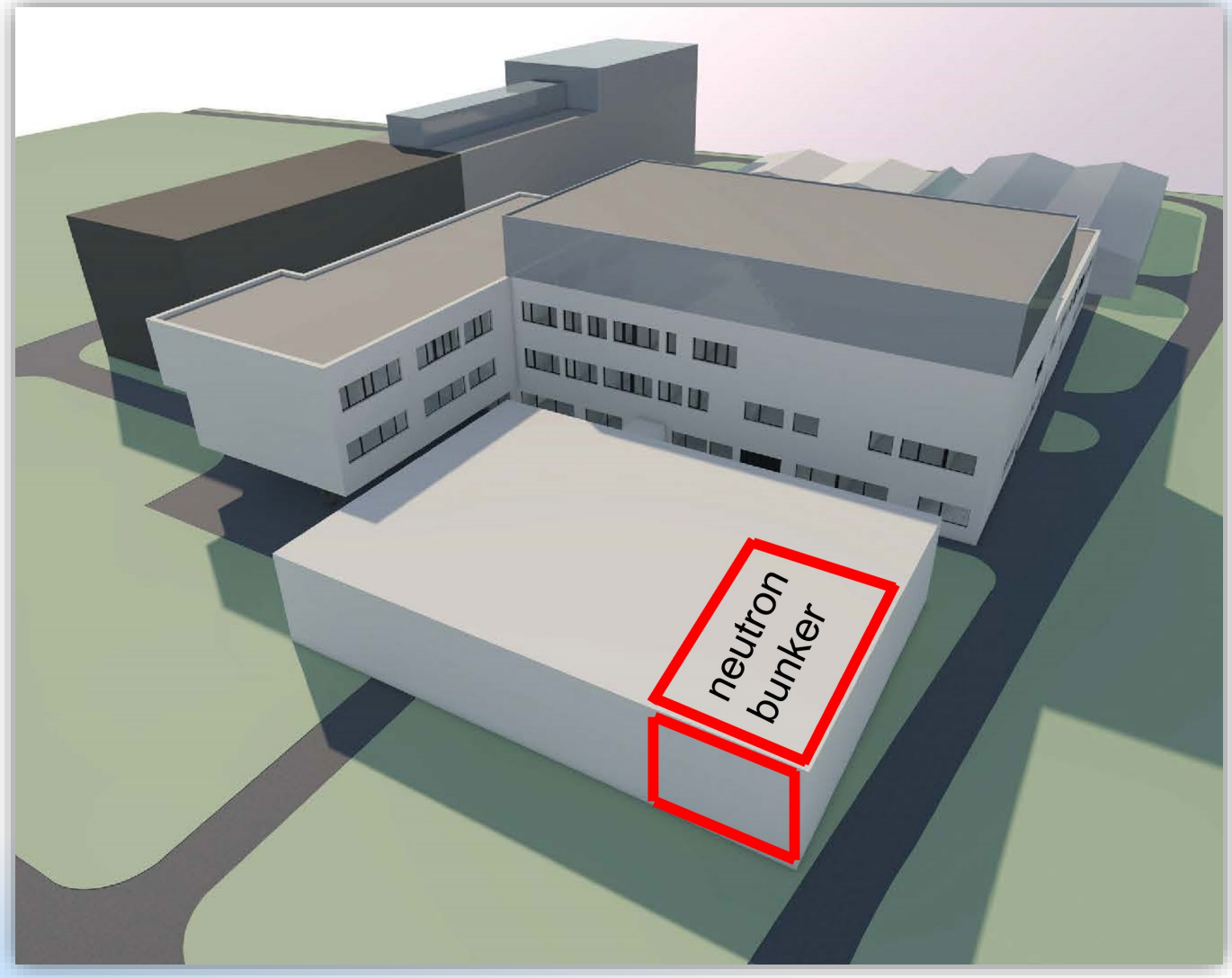
The Ion Beam Facility (IBF) project

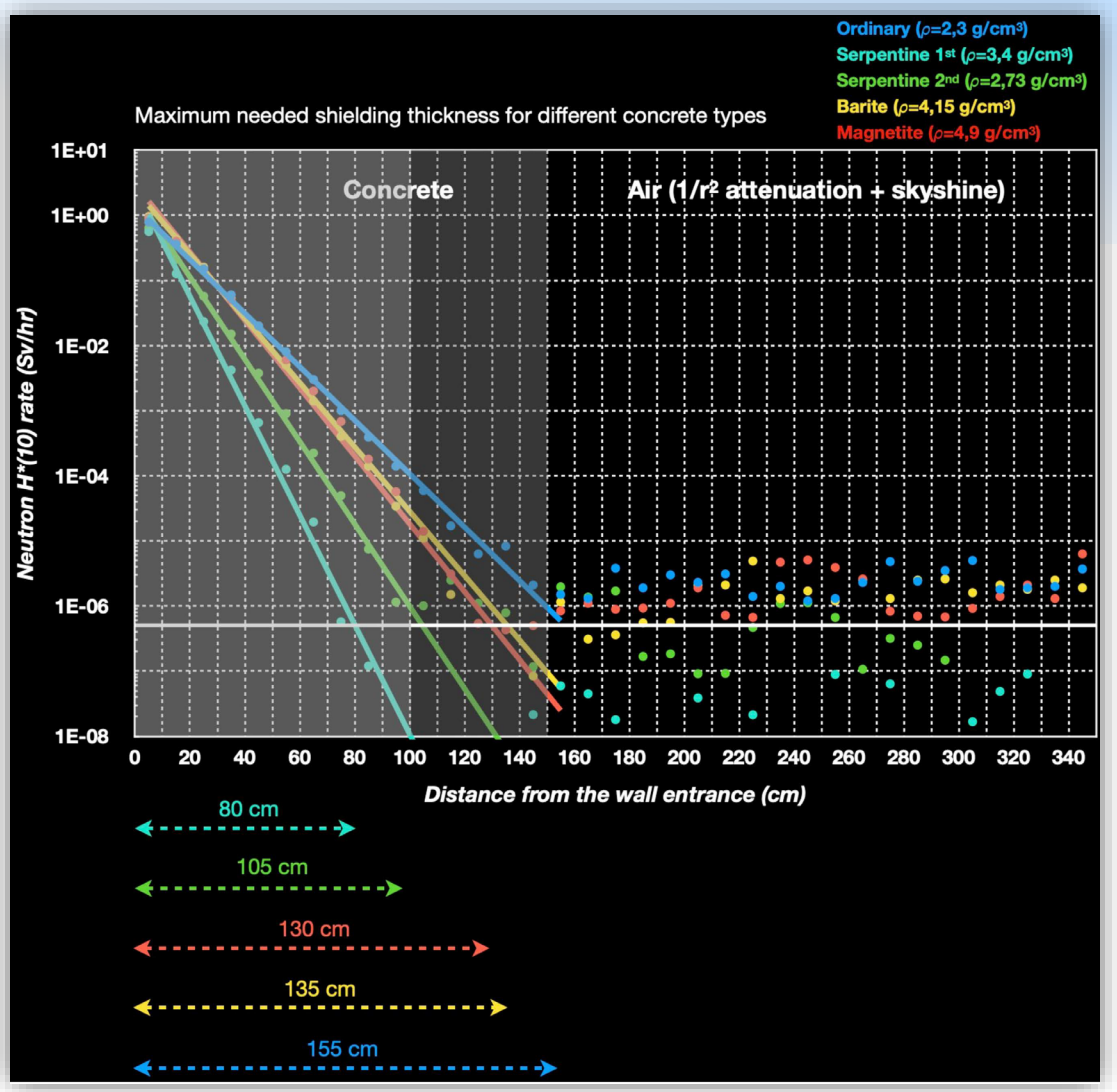
- 3 MV Tandem with 2 sources (Duo & Sputter)
- Neutron hall (1.5 m concrete) to host:
  - a neutron production target (with protons)
  - DD & DT Generators
- IBA end-station & Microbeam (Phase 1)
- Detectors for γ-, X-ray & particles
- Digital electronics / DAQ systems

Building:	1.100.000 €
Accelerator :	2.640.000 €
Beamlines:	480.000 €
Exp. Setups / sc. instrum.:	680.000 €
Neutron production station and associated instrumentation:	200.000 €
TOTAL	5.100.000 €

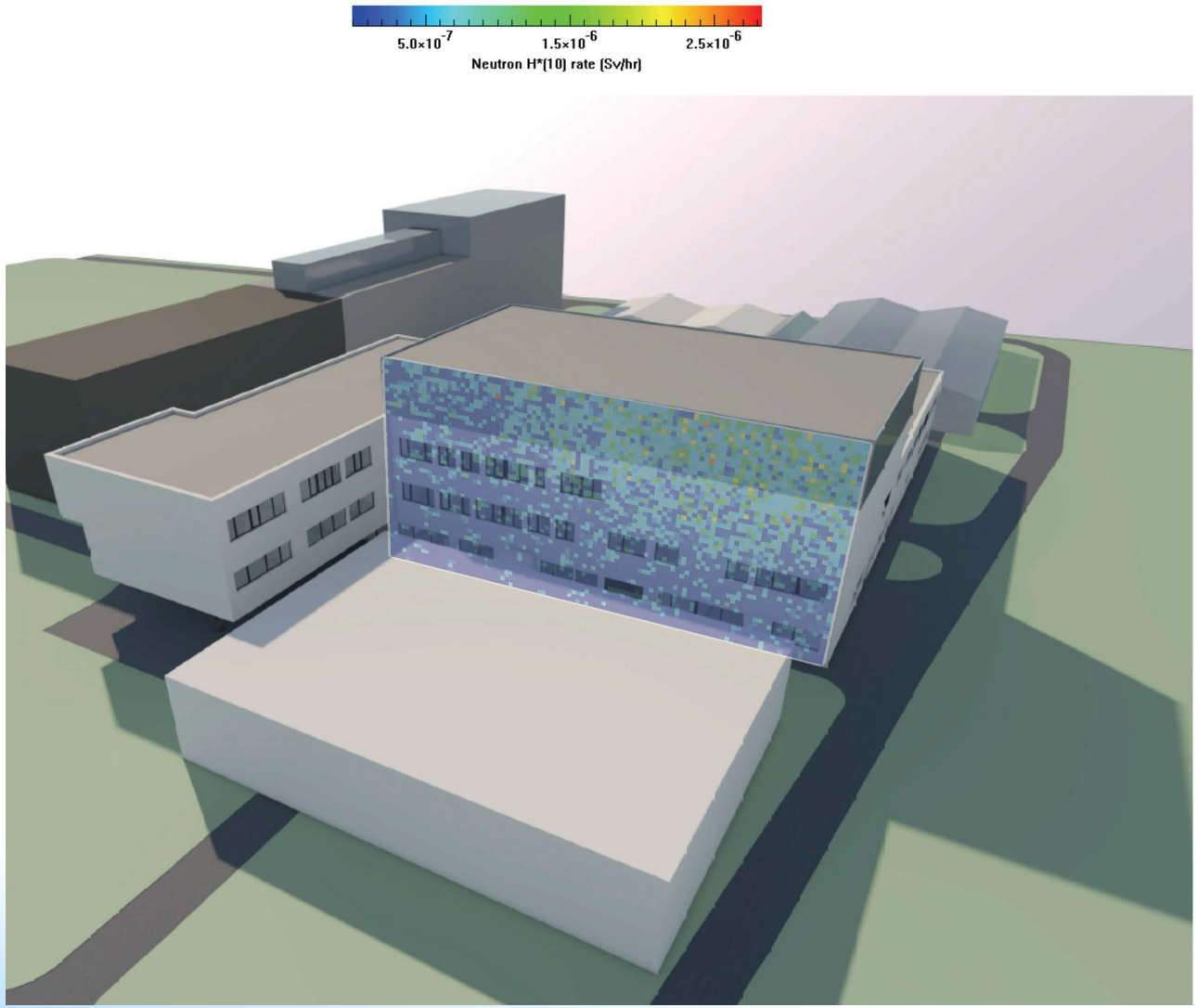


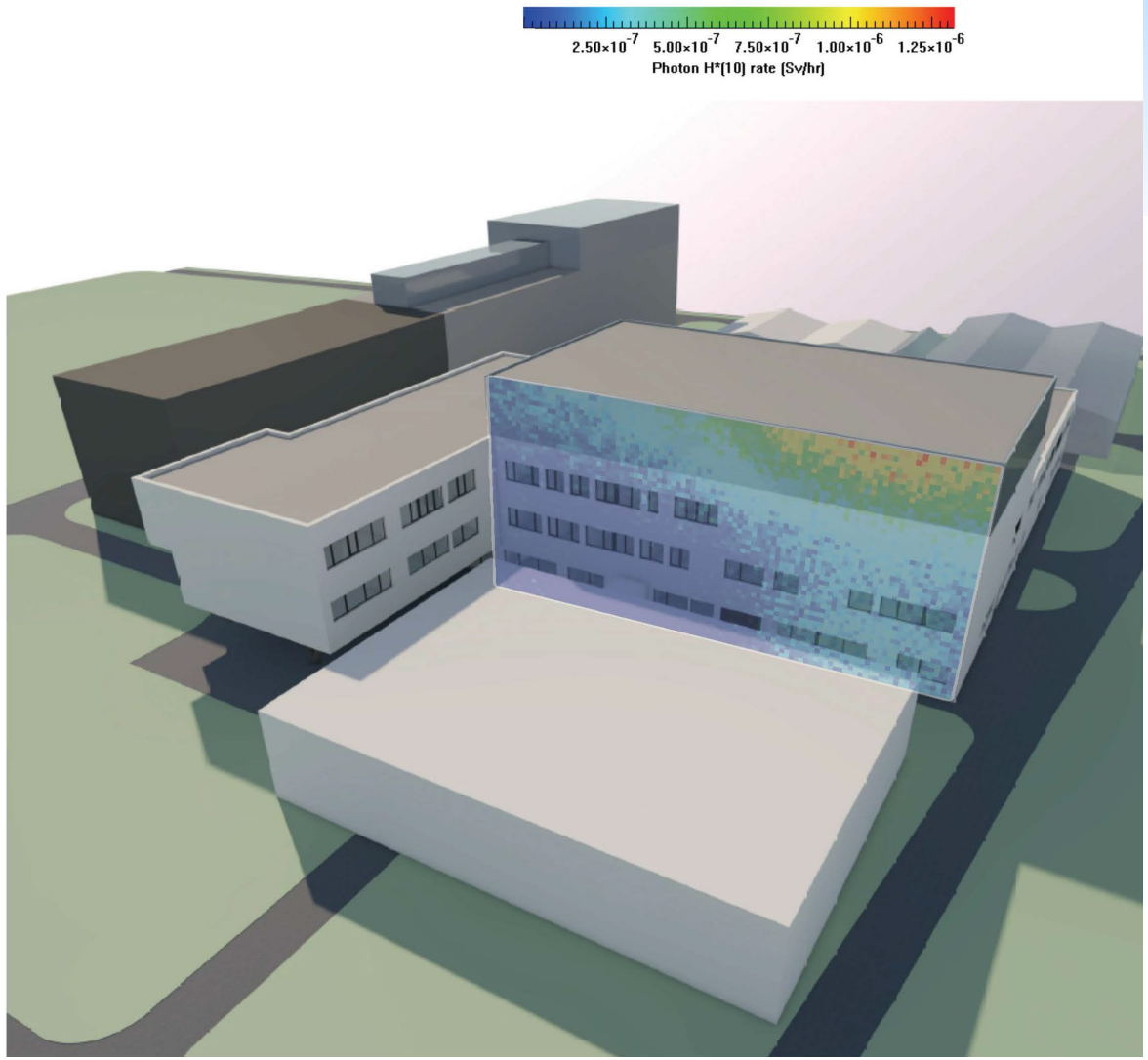
The Ion Beam Facility (IBF) project





The Ion Beam Facility (IBF) project





IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Thank you for your attention

s.charisopoulos@iaea.org