Ion Beam Analysis Facilities Overview

3MV Tandetron - Cape Town

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6MV Tandem - Johannesburg

science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

IAEA
International Atomic Energy Agency

NRF
National Research Foundation
iThemba LABS
Laboratory for Accelerator Based Sciences

Tandetron Laboratory

K200 Separated Sector Cyclotron (SSC)

K11 Solid Pole Injector Cyclotron for Light and Heavy Ions (SPC2)

K8 Solid-Pole Injector Cyclotron for Light Ions (SPC1)

11 MeV Siemens Eclipse PET Cyclotron

70 MeV cyclotron

IBA Facilities in Africa

- Atomic Energy Authority of Egypt
- Ghana Atomic Energy Commission
- Centre for Energy Research and Development (CERD)
- Institute for Nuclear Studies of Algiers
- iThemba LABS

Atomic Energy Agency of Egypt

- Tandem Accelerator Facility at Inshas (Nuclear Reactions Laboratory)
- 3 MV Tandem Electrostatic Accelerator (MC+ from HVEE)
- 3 Beamlines :
  - RBS – Channeling, target chamber, sample manipulator, target holder (cooling + heating stage)
  - PIXE and PIGE Analysis
  - Fast neutron production – water cooled target holder + neutron detector

Ghana Atomic Energy Commission

- Project started in 2008 and accelerator was commissioned in March 2016
- 1.7 MV Pelletron Accelerator installed – donation from the Government of Netherlands.
- IAEA financed its refurbishment, purchase of a complete beamline and installation.
- 7 Research scientist, 2 technicians/technologist
- 1 Beamline

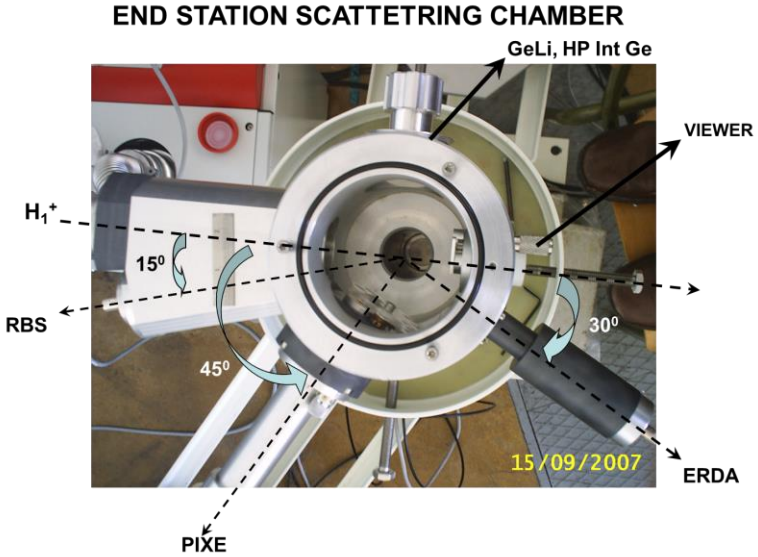
Institute for Nuclear Studies of Algiers

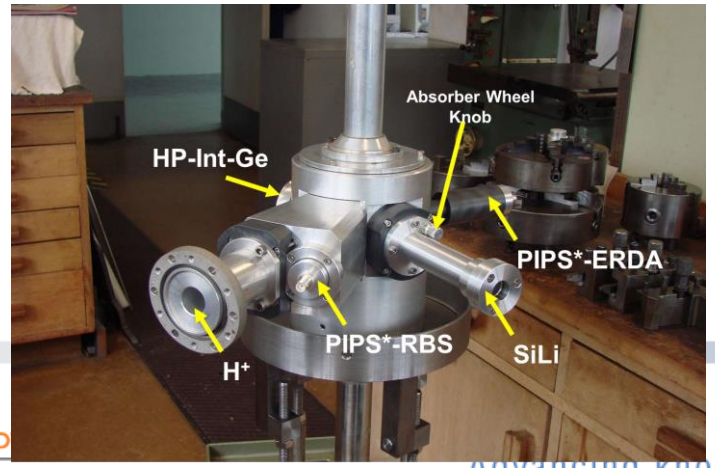
- Three charged particles accelerators have been installed:
  - 3 MV Van de Graaff accelerator (1959)
  - 0.6 MV Accelerator (1959)
  - 2 MV Van de Graaff accelerator (1960)
- 3 MV Tandem V.d.G was upgraded to 3.75 MV in 1976
- 2 Beamlines :
  - General purpose analysis
  - Neutron production and application – NAA
- 10 researchers and 3 technicians

Centre for Energy Research and Development (CERD)

- Obafemi Awolowo University, Ile-Ife, Nigeria
- Commissioned in September 2008 – one beamline
- 1.7 MV Pelletron Accelerator from NEC
- 2 beamlines are active at the moment – splitting magnet has a provision for 5 beamlines.
  - General purpose End Station for PIXE, RBS, PIGE and ERDA
- 2 Research scientist, 3 technicians/technologist.

CONSTRUCTION AND INSTALLATION OF END-STATION FOR ION BEAM ANALYSIS FOR THE CERD 1,7 MV TANDEM ACCELERATOR





(*) PASSIVATE IMPLANTED PLANAR SILICON DETECTOR

MEMORANDUM OF UNDERSTANDING

BETWEEN

iTHEMBA LABORATORY FOR ACCELERATOR BASED SCIENCES

(Herein referred to as iThemba LABS)

a national facility of the National Research Foundation operating under the NRF Act, No. 23 of 1998, and represented by Dr Zeblon Vilakazi in his capacity as Director at iThemba LABS

AND

THE CENTRE FOR ENERGY RESEARCH AND DEVELOPMENT AT OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA

a tertiary educational institution, duly established under the applicable Laws of Nigeria, herein represented by Prof Gabriel A. Osinkulo in his capacity as Director of the Centre for Energy Research and Development and he being duly authorised thereto

(herein referred to as CERD)

RELATING TO:

CONSTRUCTION AND INSTALLATION OF END-STATION FOR THE CERD 1,7 MV TANDEM ACCELERATOR, referred to a “the Field

CONSTRUCTION AND INSTALLATION OF END-STATION FOR ION BEAM ANALYSIS FOR THE CERD 1,7 MV TANDEM ACCELERATOR

6 MV Tandem @ TAMS Laboratory

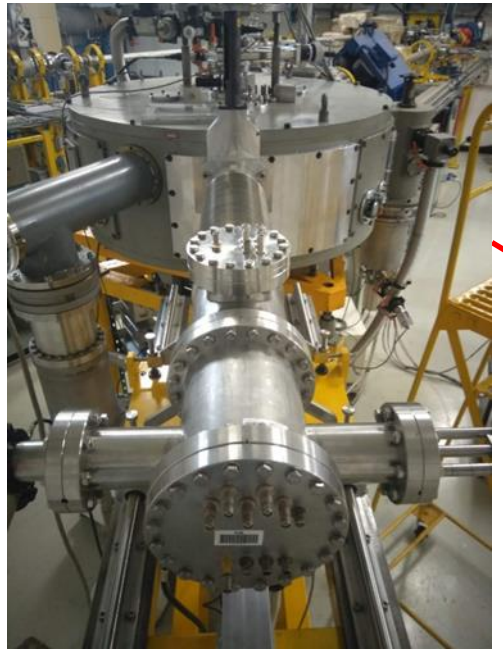
Main activities : AMS and IBA

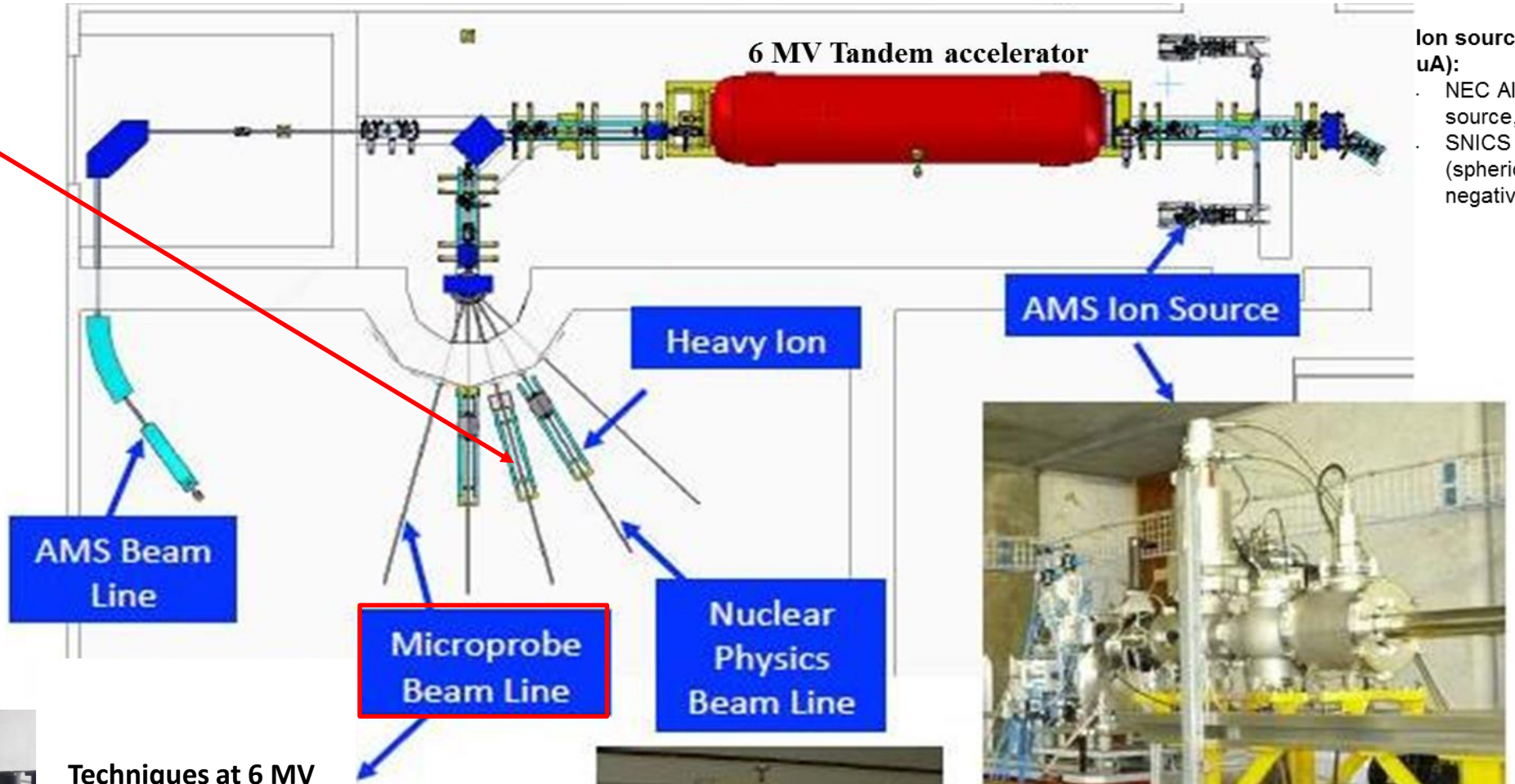
3 MV Tandetron @ Tandetron Laboratory

Main activities : IBA and Astrophysics

6 MV Tandem Accelerator Layout

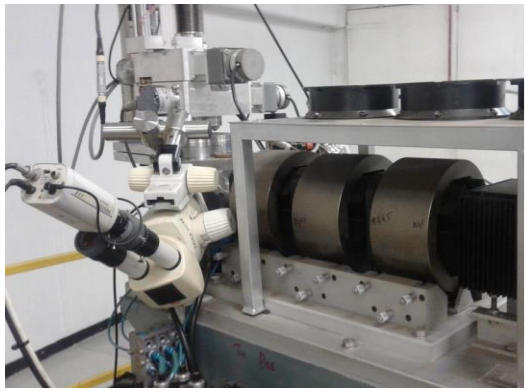
HI-ERDA





Ion sources (up to 5 uA):

- NEC Alphatross He^+ source,
- SNICS 860C (spherical ionizer) negative ion source



Techniques at 6 MV Tandem Facility:

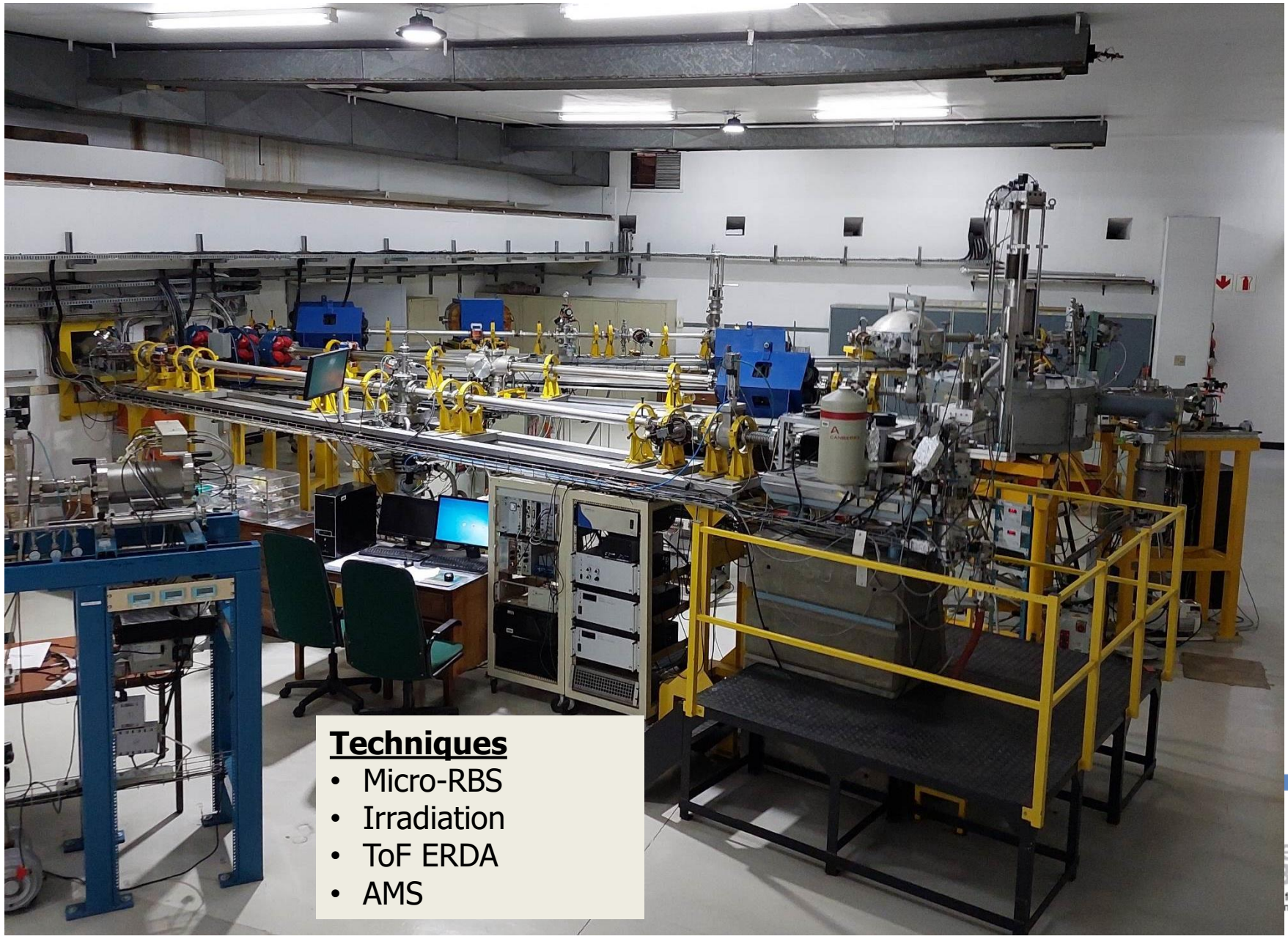
- RBS
- Irradiation
- Micro-PIXE

6 MV Tandem Accelerator Layout

Ion sources (up to 5 uA):

NEC Alphatross He^+ source

SNICS 860C (spherical ionizer) negative ion source



Techniques

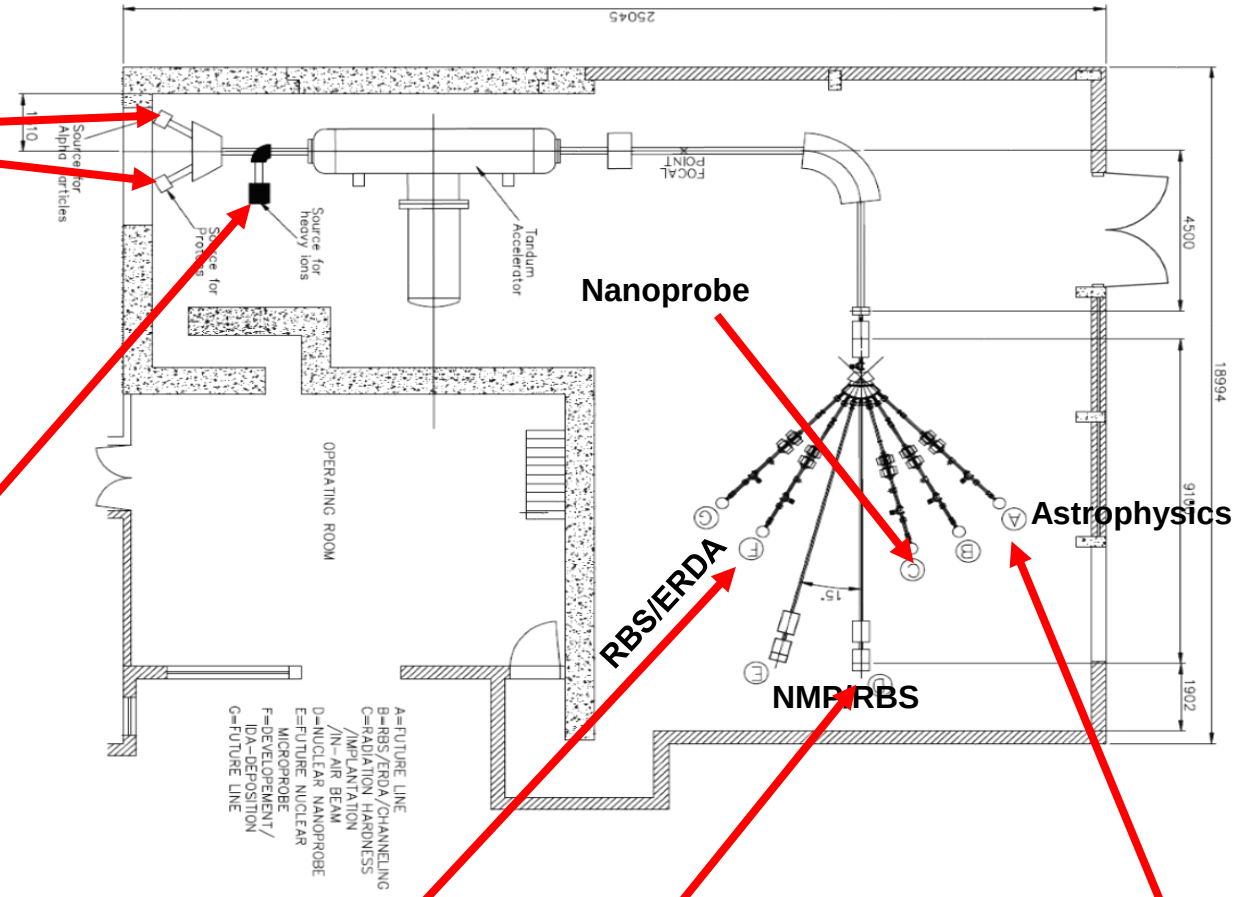
- Micro-RBS
- Irradiation
- ToF ERDA
- AMS

3 MV Tandetron Accelerator Layout

$_1H^+$: 150 eμA @ TV = 200 kV
$_1H^+$: 200 eμA @ TV = 1.0 MV
$_1H^+$: 200 eμA @ TV = 3.0 MV

$_2D^+$: 150 eμA @ TV = 200 kV
$_2D^+$: 200 eμA @ TV = 1.0 MV
$_2D^+$: 200 eμA @ TV = 3.0 MV

$_4He^+$: 8 eμA @ TV = 200 kV
$_4He^{2+}$: 25 eμA @ TV = 1.0 MV
$_4He^{2+}$: 25 eμA @ TV = 3.0 MV



Nanoprobe

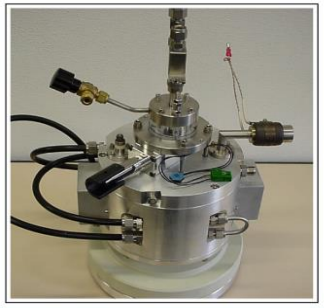
Astrophysics

RBS/ERDA

NMP/RBS

NEGATIVE SPUTTER ION SOURCE

Model 860A and 860C

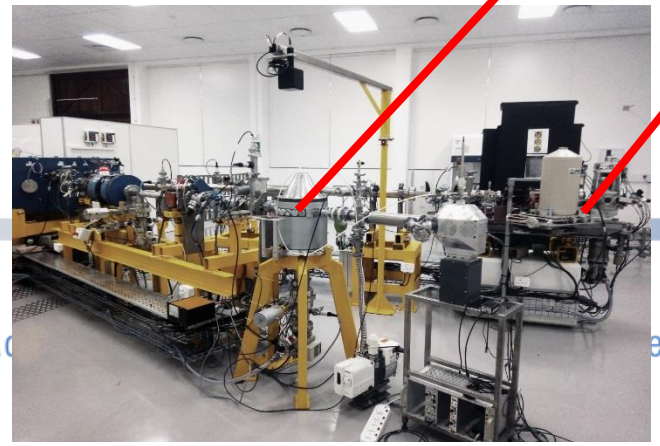


Features

- Easy operation and maintenance
- High intensity ion beams of almost all elements in the periodic table
- Beam currents up to 150 μA
- Low beam emittance
- Easy cesium reservoir loading
- Lifetime cesium charge > 1000 hours
- Easy (ex)change of source materials

Radius	1.5 m
Maximum field	1.28T
Pole gap	45 mm
Maximum mass energy product ($M_{inj}E_{inj}/q^2$)	165 MeV amu
Maximum energy Silver 4+	25.3 MeV

$^{11}B^-$	10 μA
$^{12}C^-$	100 μA
$^{16}O^-$	100 μA
$^{28}Si^-$	100 μA
$^{31}P^-$	30 μA
$^{58}Ni^-$	30 μA
$^{63}Cu^-$	20 μA
$^{75}As^-$	15 μA
$^{197}Au^-$	80 μA



Overview of IBA Facilities @ Tandetron Laboratory

Ion beam analysis

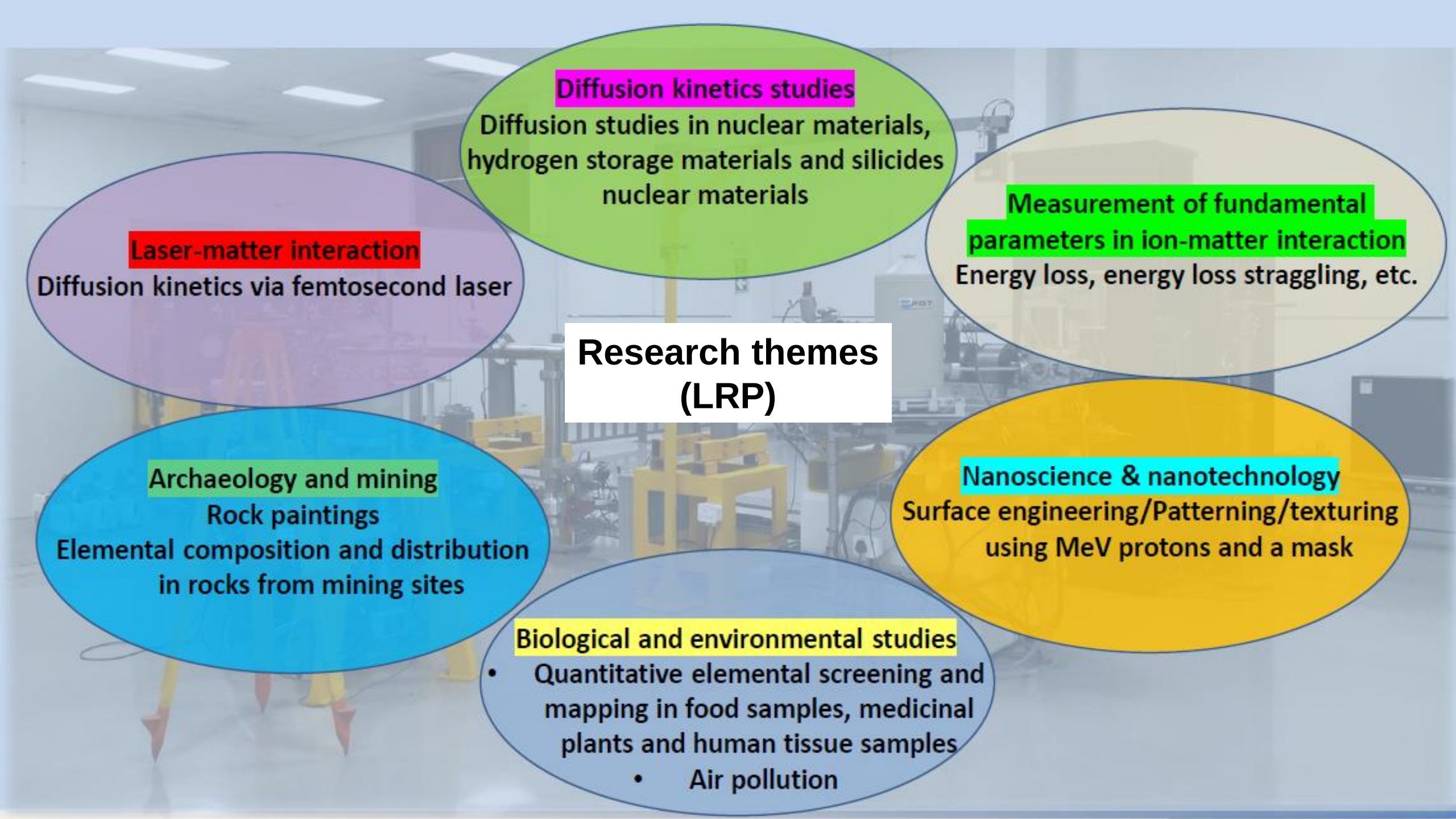
Nuclear-Astrophysics

Ion sources (up to 700 uA):

- He Multicusp Model SO130 positive extraction
- H- and D- Multicusp Model SO120 direct negative extraction
- Cesium negetive sputter for heavy ions

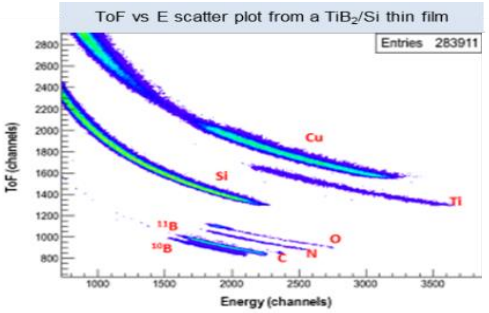
Techniques:

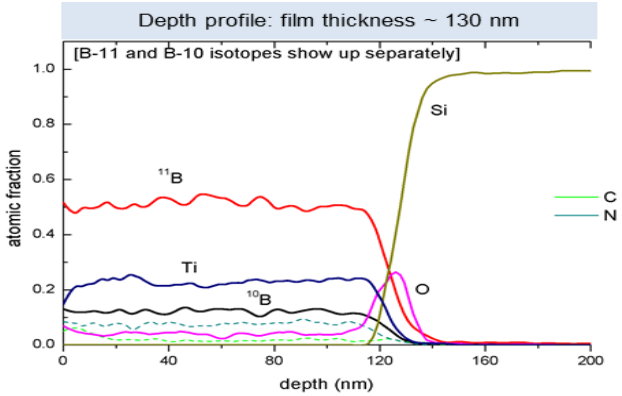
- RBS and In-Situ real-time RBS (600^{o}C)
- ERDA and In-Situ real-time ERDA (600^{o}C)
- RBS channelling
- Irradiation
- Micro-PIXE
- Proton beam writing

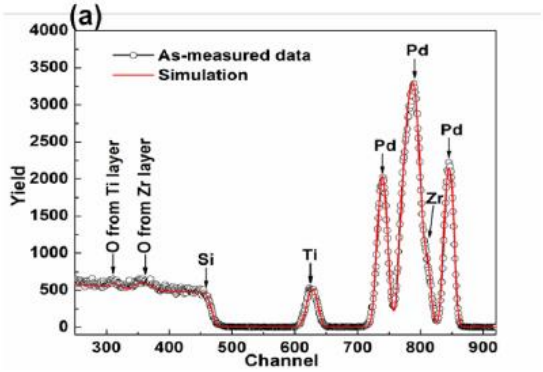

Diffusion kinetics studies
Diffusion studies in nuclear materials, hydrogen storage materials and silicides nuclear materials
Laser-matter interaction
Diffusion kinetics via femtosecond laser
Measurement of fundamental parameters in ion-matter interaction
Energy loss, energy loss straggling, etc.
Research themes (LRP)
Archaeology and mining
Rock paintings
Elemental composition and distribution in rocks from mining sites
Nanoscience & nanotechnology
Surface engineering/Patterning/texturing using MeV protons and a mask
Biological and environmental studies
• Quantitative elemental screening and mapping in food samples, medicinal plants and human tissue samples
• Air pollution

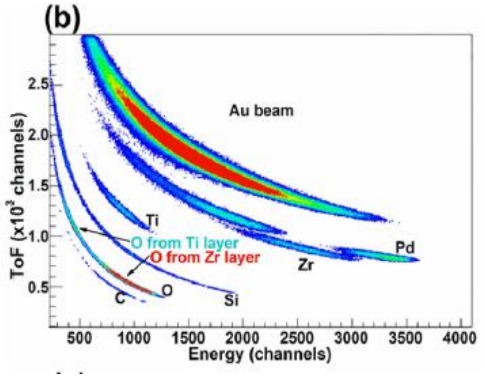
Theme 1: Measurement of fundamental parameters in ion-matter interaction (IAEA contract (2021- 2025))

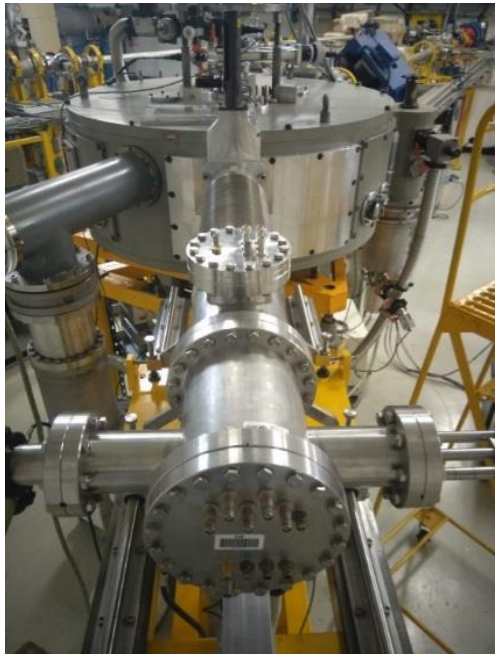
- *CRP on Development and Application of Ion Beam Techniques for Materials Irradiation and Characterization Relevant to Fusion Technology (F11023)*
  - experimental stopping force, energy loss straggling data of heavy ions in a wide range of elemental i.e. refractory metal (tungsten (W), molybdenum (Mo), chromium (Cr), tantalum (Ta), niobium (Nb), hafnium (Hf), and rhenium (Rb) and compound target materials and in thin film materials
  - *continuous range* of energies from about **0.1 MeV/u to 1.0 MeV/u**

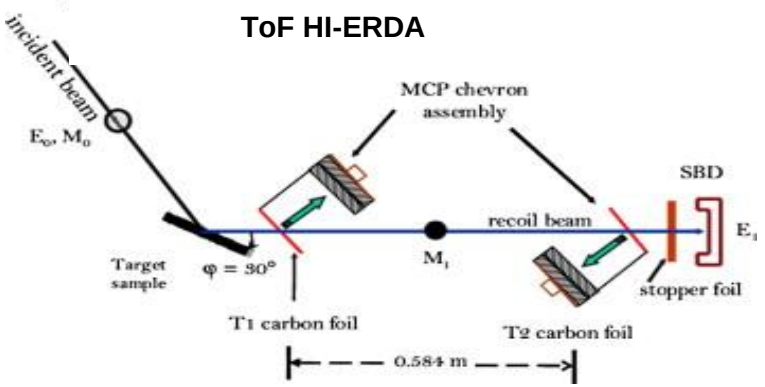


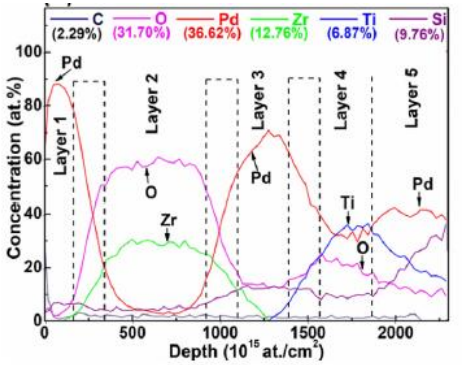


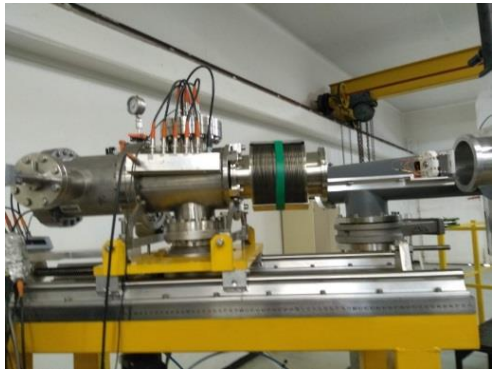




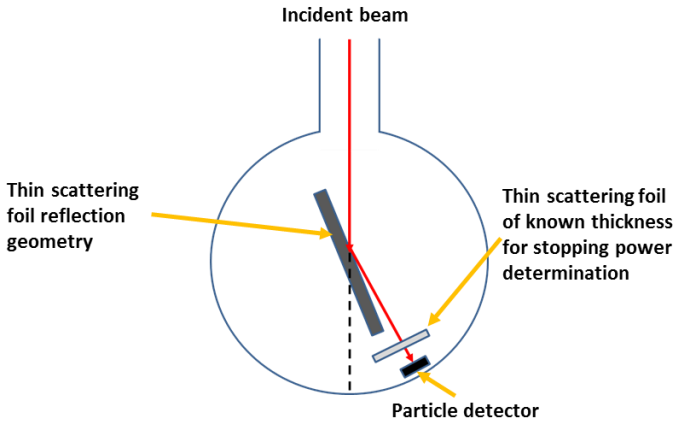


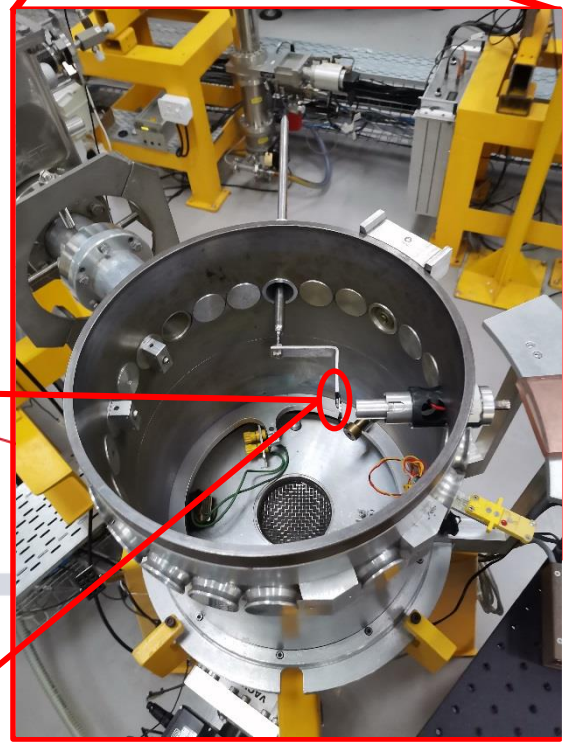




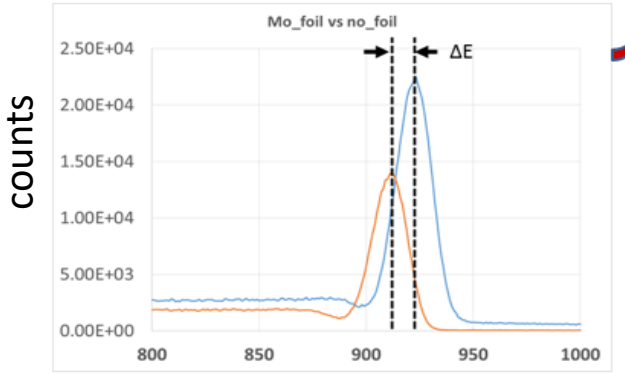


Stopping force of 20 – 2000 keV of proton and 40 8000 keV He ions in ^{184}W, ^{52}Cr and ^{96}Mo by forward scattering method

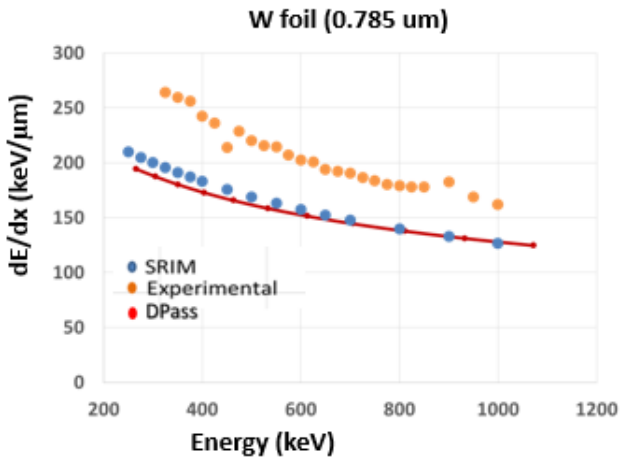




Energy loss $\Delta E = E_{without\_foil} - E_{with\_foil}$



Stopping force $[S] = \frac{\Delta E}{\Delta x}$

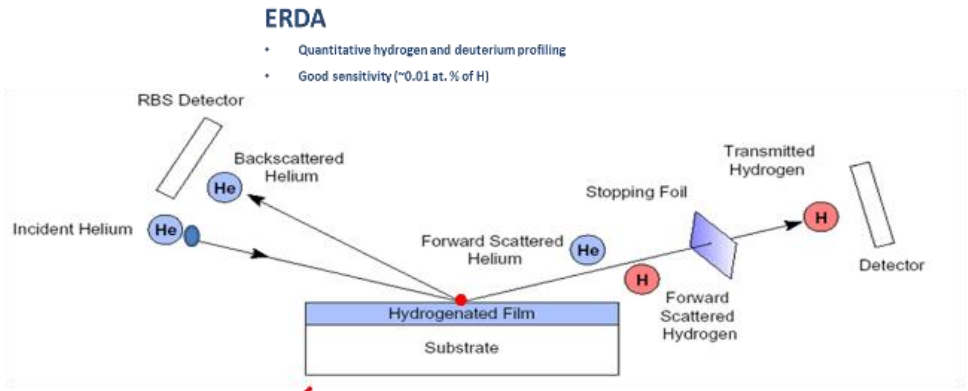


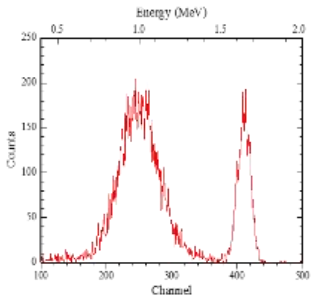
Ref.: IAEA hands-on training course using research reactors and accelerators

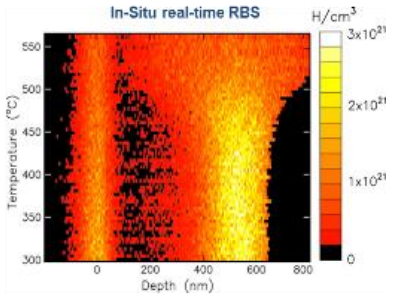
Theme 2: Kinetic diffusion studies (current temp. 600°C)

- *Diffusion studies in nuclear materials:*
  - Materials such as SiC and glassy carbon implanted with heavy ions with a purpose of investigating structural changes induced by swift heavy ions.

- *Diffusion studies in Silicides:*
  - Materials such as SiC and glassy carbon implanted with heavy ions with a purpose of investigating structural changes induced by swift heavy ions.

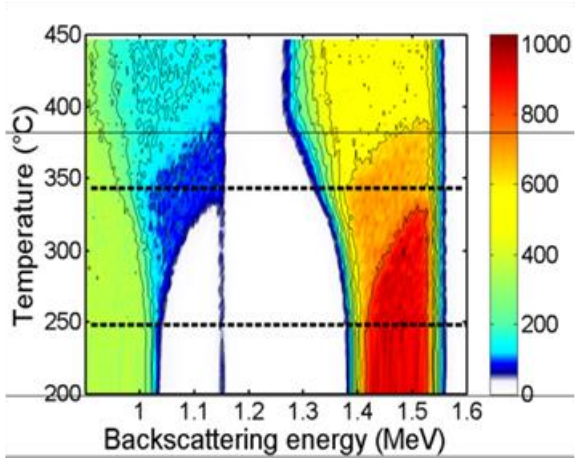


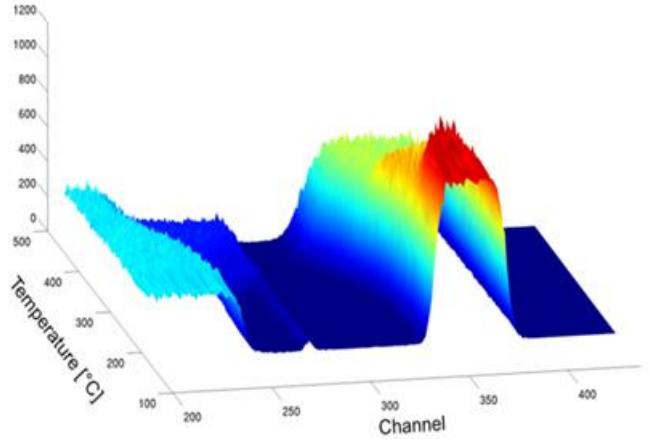




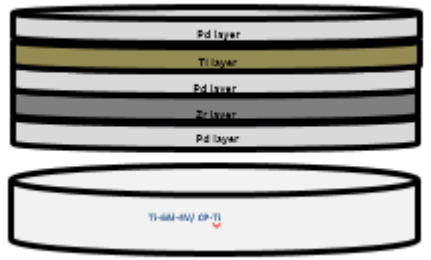
In-Situ real-time RBS

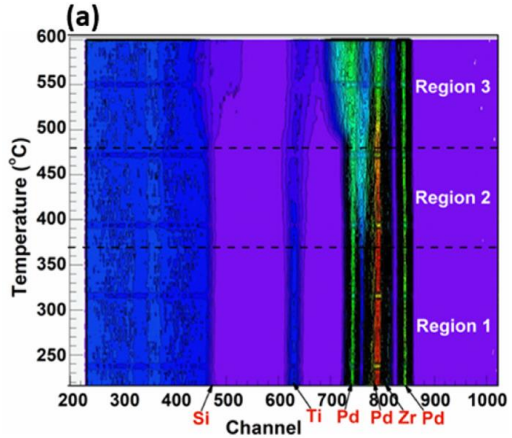
- Inter-diffusion kinetics of thin films (metals, silicides, etc.)
  - ramp at 2° C/min in vacuum and collect RBS spectrum every 30s





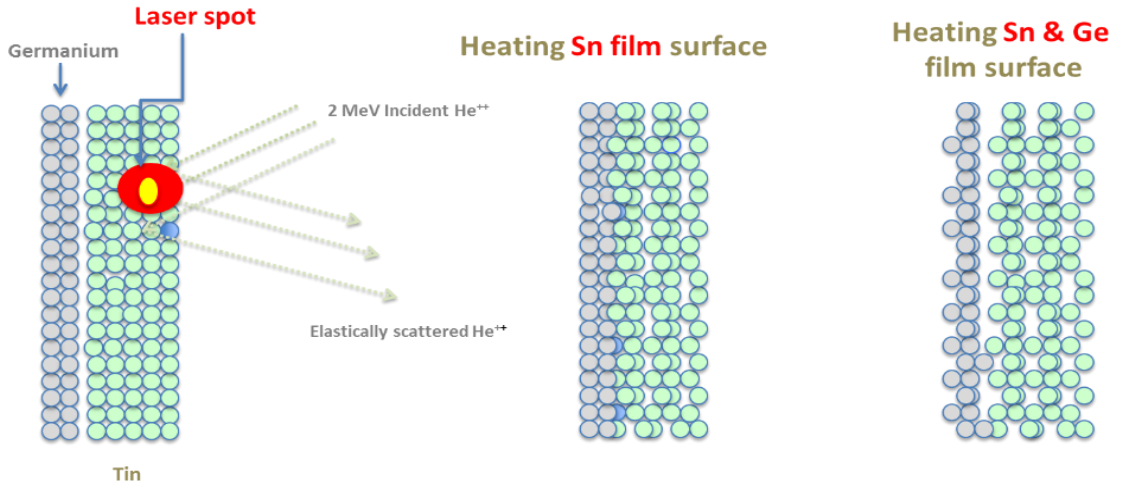
- *Hydrogen storage materials:*
  - Characterization of Ti-Pd based multilayer thin films using Elastic Recoil Detection Analysis (ERDA) for hydrogen storage application

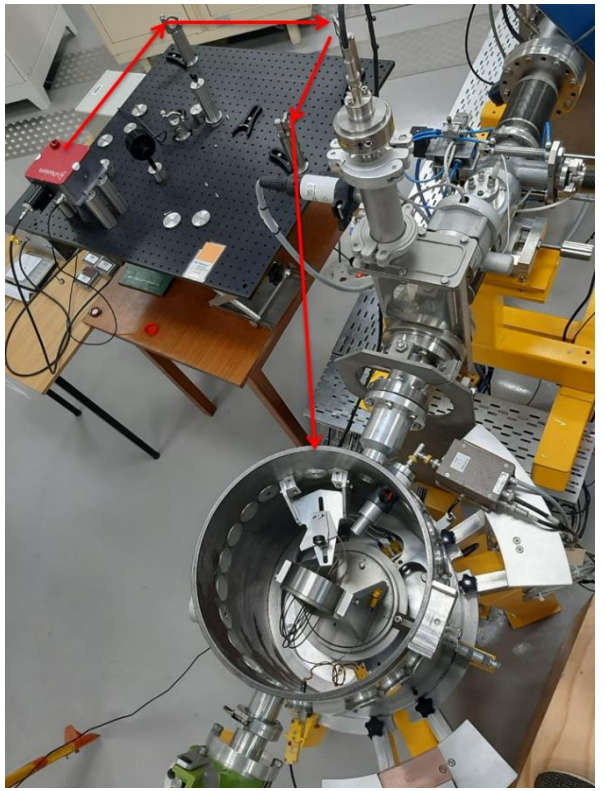


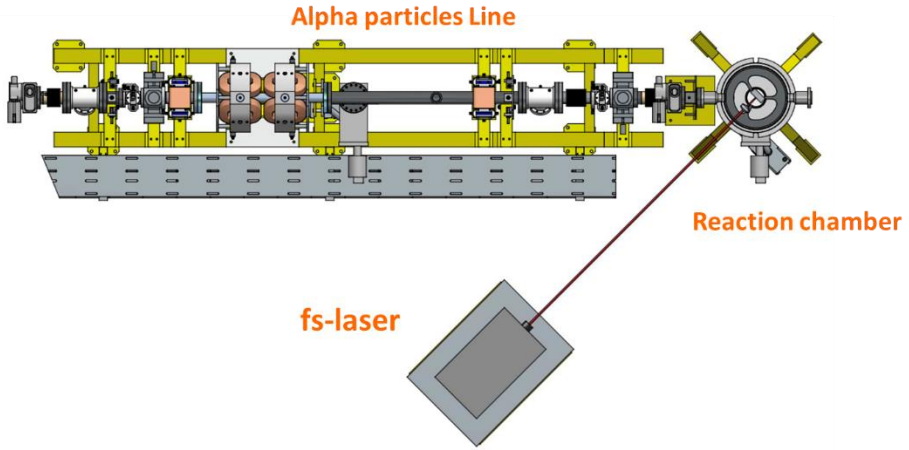


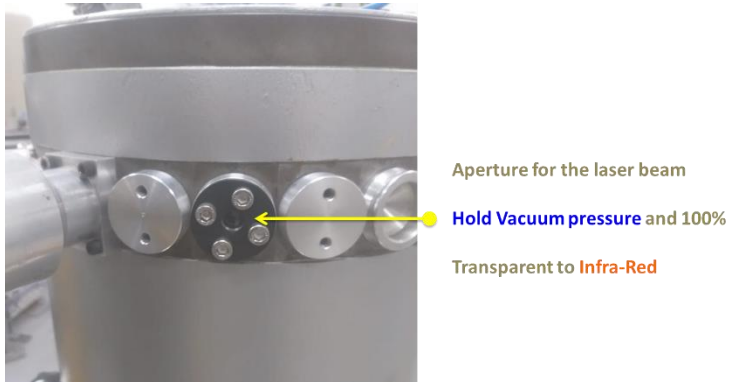
Theme 3: Laser-Matter Interaction

- *Diffusion studies in different materials for electronics (diffusion kinetics vs femtosecond laser):*
  - Materials such as Sn and Ge to form compounds of various stoichiometry



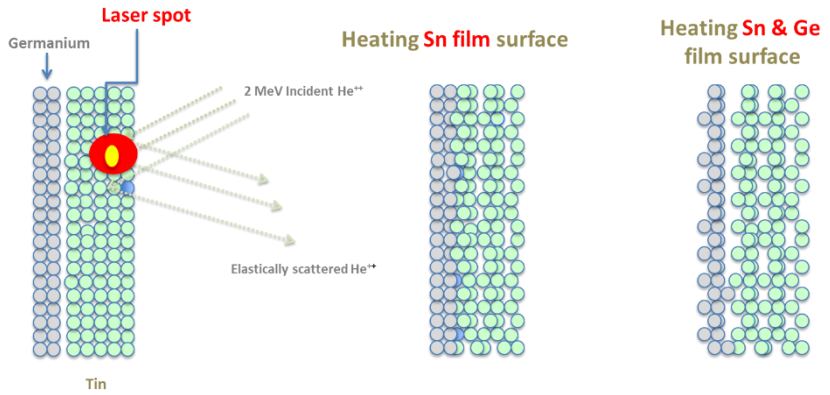


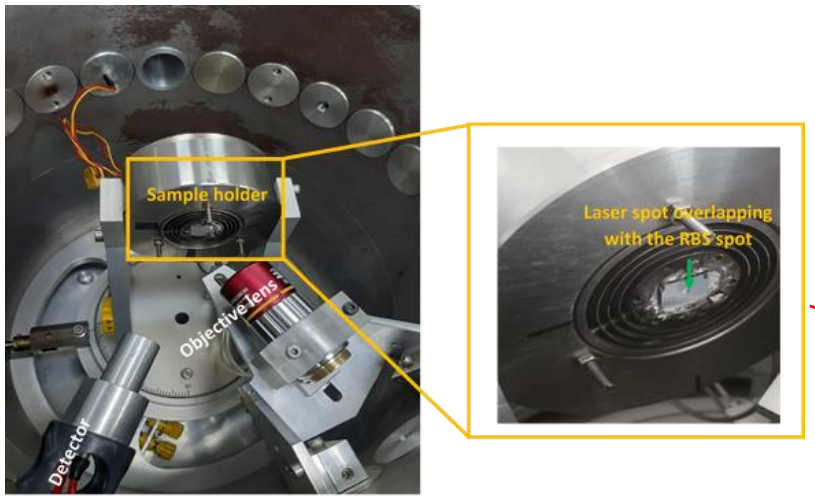


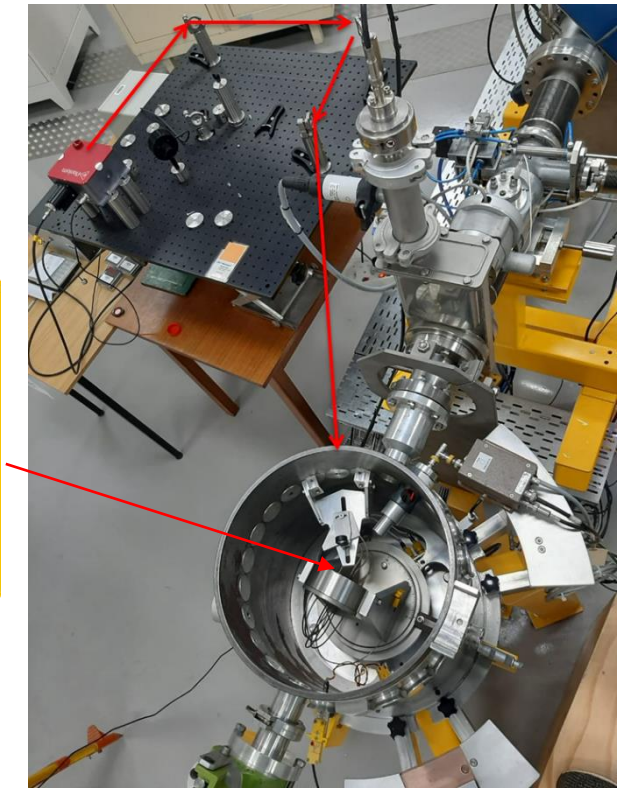


Laser-Matter Interaction Set-Up

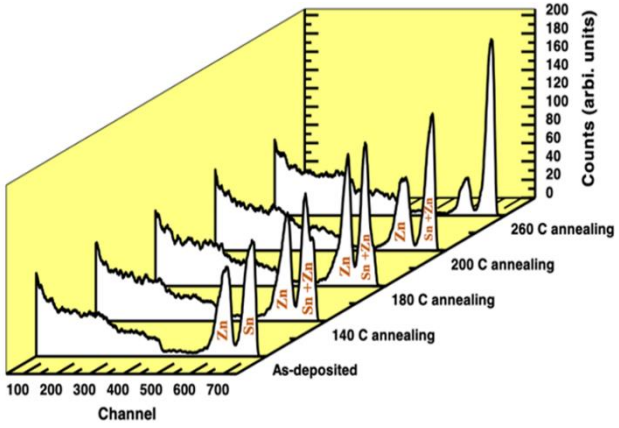
- Diffusion studies in different materials for electronics (diffusion kinetics vs femtosecond laser):
  - Materials such as Sn and Ge to form compounds of various stoichiometry

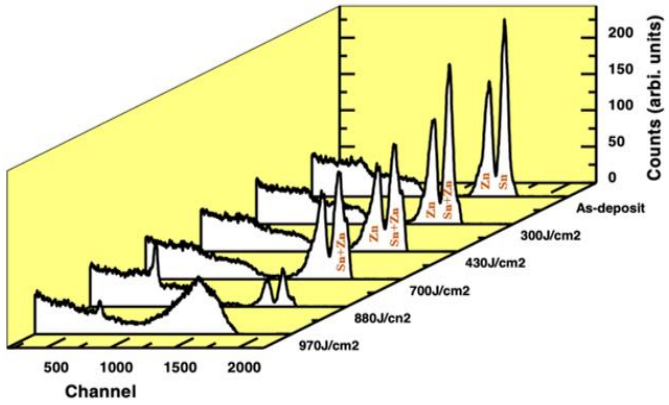


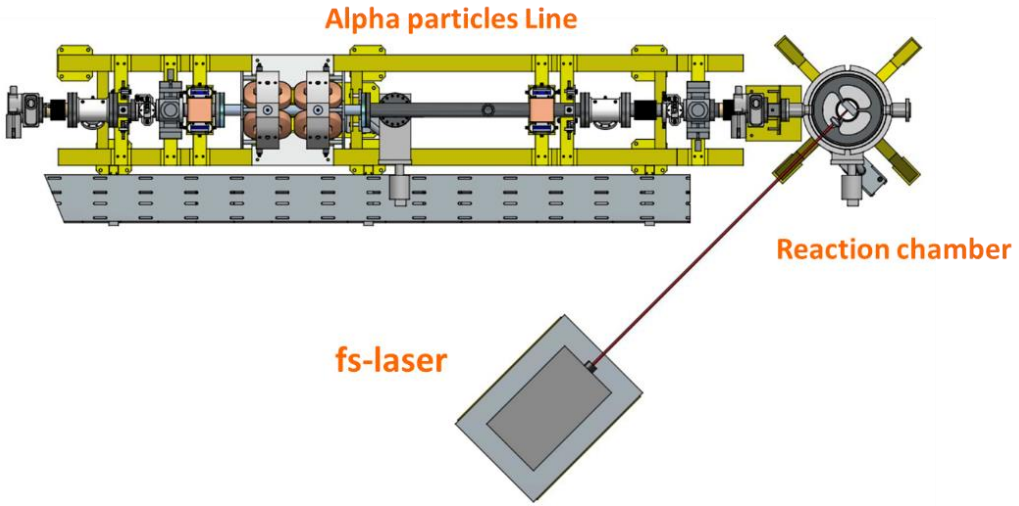




Isothermal vs non-isothermal



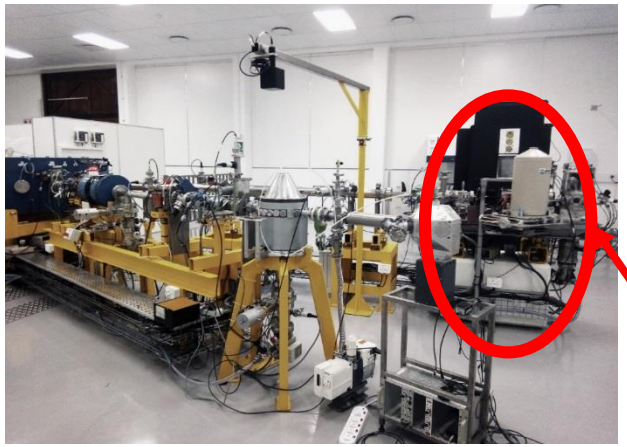


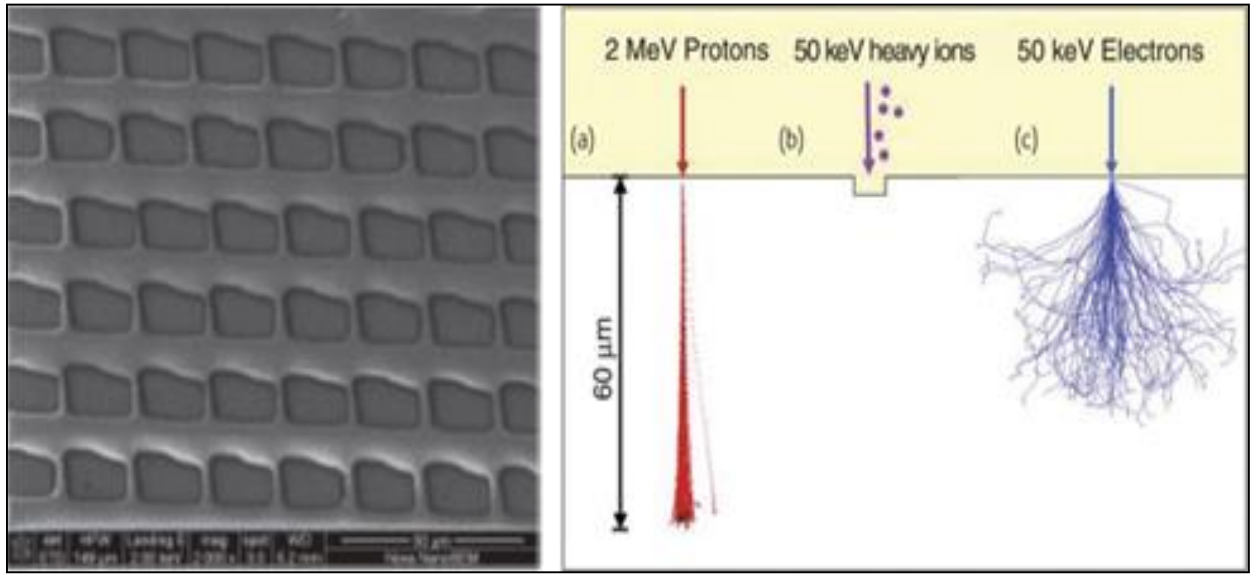


Ms. Goele Magchiels and Prof A. Vantomme

Theme 4: Nanoscience and Nanotechnology

- *Surface engineering using a mask:*
  - Texturing and patterning using MeV protons
    - Scanning beam on the surface of a masked polymer film to create a pattern.





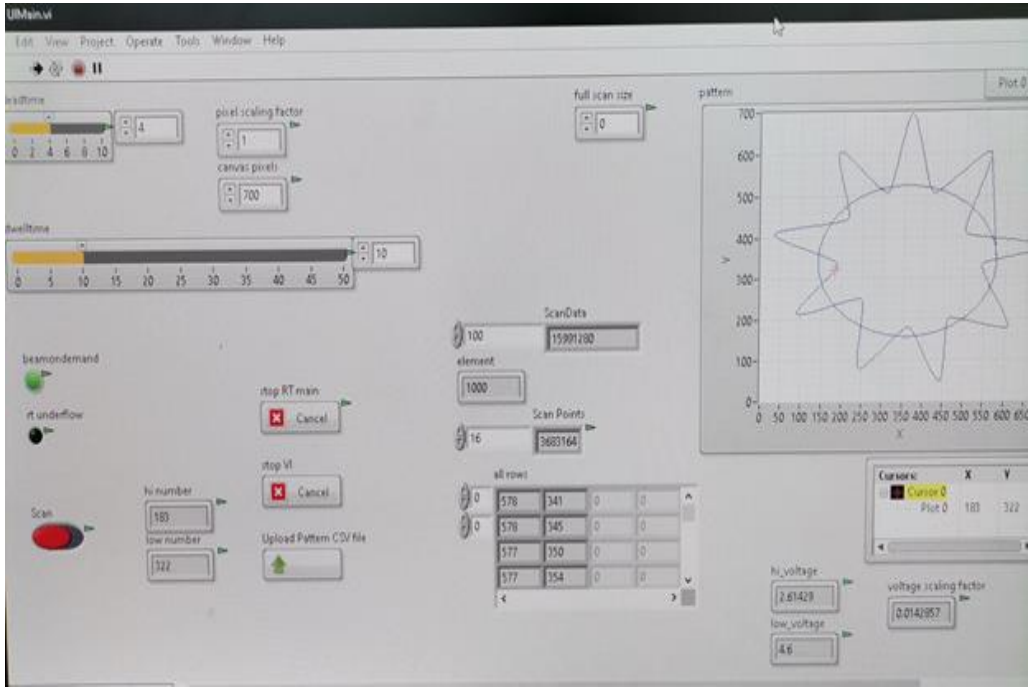
- Required beam spot size below 1 µm x 1 µm
- Current beam spot size 2 µm x 1.5 µm

- *Surface engineering using a designed pattern:*
  - Texturing and patterning using MeV protons
    - Scanning beam on the surface of a polymer film to create a pattern; software controlled mechanism.

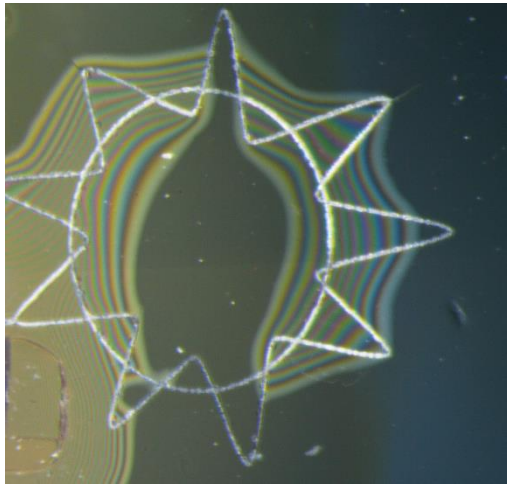
Proton beam writing software

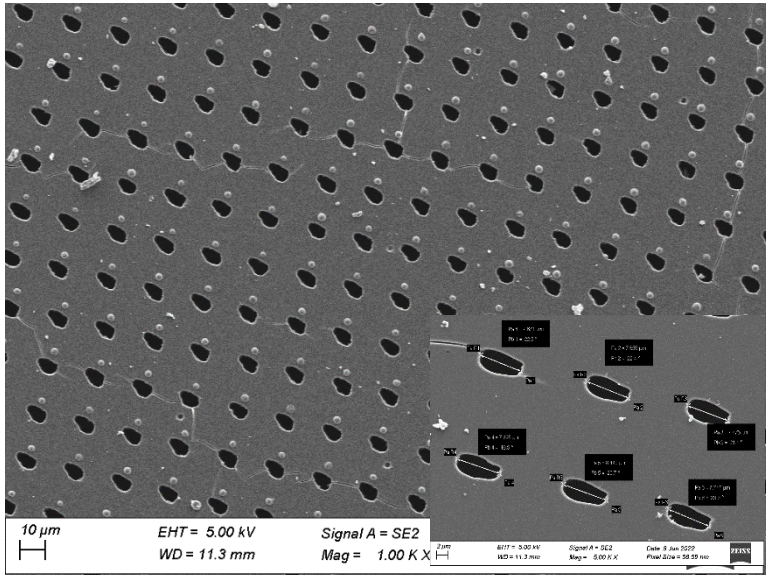
- Surface engineering using a designed pattern:
  - Texturing and patterning using MeV protons
    - Scanning beam on the surface of a polymer film to create a pattern; software controlled mechanism.

- Required beam spot size below 1 μm x 1 μm
- Current beam spot size 2.6 μm x 1.99 μm

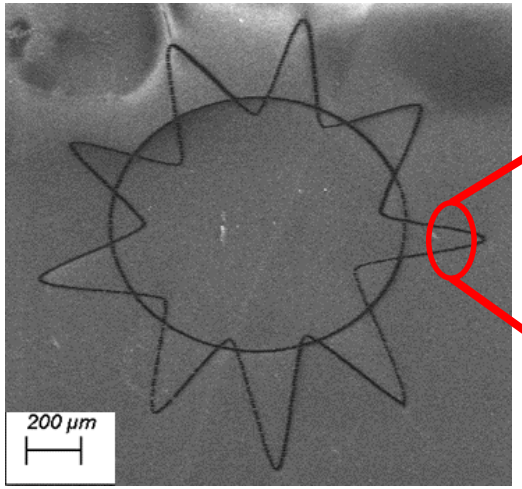


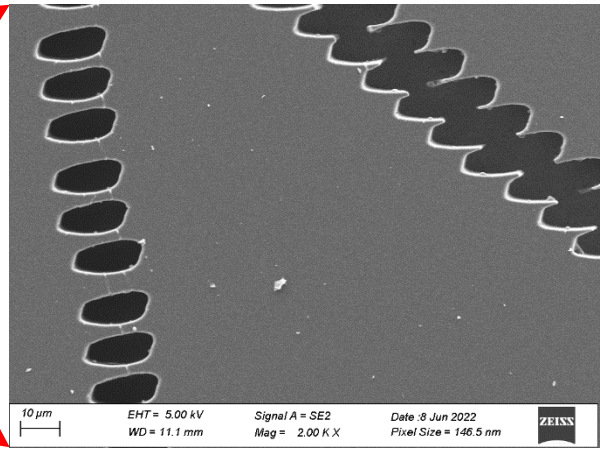
Optical microscope image





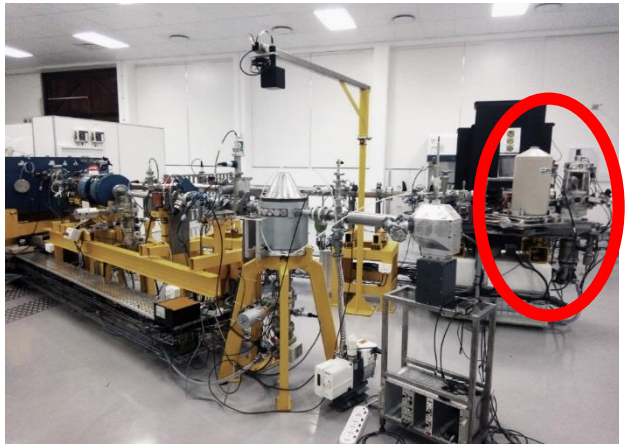
SEM image



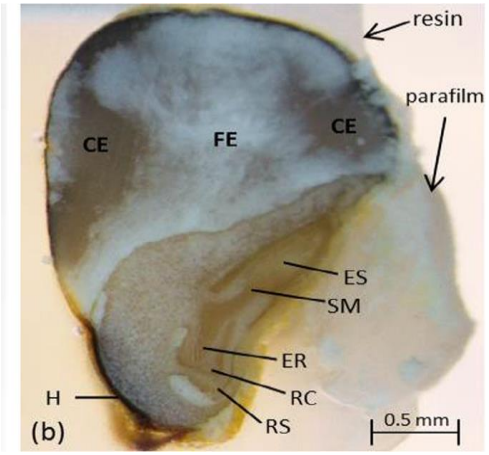


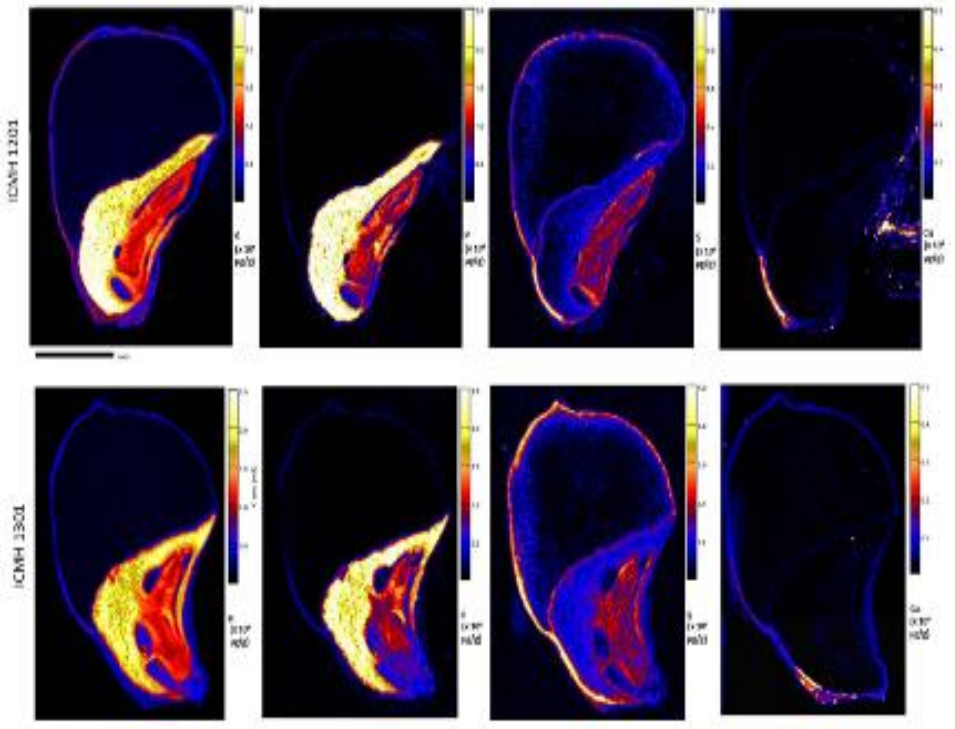
Theme 4 and 5 (PIXE): Biological, environmental, and archeological

- *Elemental composition and distribution in:*
  - rocks, soil samples from mining sites
  - Ancient rock paintings



- *The use of nuclear analytical techniques in environmental toxicology studies*
  - Heavy metals originating from geogenic, anthropogenic sources, or uncontrolled waste disposal may contaminate soil, air, and water bodies indirectly contaminate agricultural crops and other food sources including marine reserves.
  - Detrimental effects include:
    - Changes in environmental systems such as water, air and soil quality; leading to:
    - food insecurity and public health problems





IAEA Collaborating Centre
2021 - 2025

Collaborating Centre Activities

- Capacity building:
  - ✓Hosting visits of young researchers and scientists from Africa and other continents.
  - ✓Organizing post-graduate training courses in fields relevant to Accelerator Based Sciences extended to IAEA member states across the African continent.

- Organization and/or hosting regional and/or international scientific/technical events (workshops, conferences, collaboration meetings, etc.)

- Providing expert services for expert and other missions on request

IAEA
International Atomic Energy Agency

Training Workshop on the Operation and Maintenance of Electrostatic Accelerators and Associated Instrumentation

Hosted by the

Government of South Africa

through the

iThemba LABS

Johannesburg, South Africa

5 to 9 December 2022

Ref. No.: EVT2104016

science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

Advancing knowledge.

NRF National Research Foundation
iThemba LABS Laboratory for Accelerator Based Sciences

Workshops, Conferences and Schools

Low-Energy Nuclear Astrophysics

26-27 November 2023
Auditorium
Africa/Johannesburg timezone

- Overview
- Call for Abstracts
- Important Dates
- Registration
- Participant List
- Workshop Program

iThemba LABS is organising a workshop on Low-Energy Nuclear Astrophysics at Tandem Accelerator Mass Spectrometer (TAMS) Laboratory in **Johannesburg** from **26-27 November 2023**. There has been many years of nuclear investigations pursued at the EN Tandem Accelerator since the commissioning of the Tandem in 1973 (as part of the Schonland Institute) and the subsequent transfer of the Institute to the NRF in 2005 through running of the laboratory as a National Facility by iThemba LABS.

Funding opportunity

- **2019 – current : ** Research Project entitled **'Transnational Access to Ion-Beam Accelerator of Materials Research Department at iThemba LABS'** (hereinafter referred to as the "Research Project") which forms part of the **IAEA Coordinated Research Project 'G42008'** entitled 'Facilitating Experiments with Ion Beam Accelerators' (hereinafter referred to as the "CRP"). **IAEA Research Agreement No: 23555/R0**

Users and Collaboration in Africa

Collaborators and Users of the Platforms
Coal City University Enugu, Nigeria
Sudan University of Science and Technology, Sudan
Burkina Faso National Authority of Radiation Protection and Nuclear Safety, Burkina Faso
Nuclear Research Centre of Algiers, Algeria
Blinda University, Algeria
Cheikh Anta Diop University, Senegal

Thank you for your attention

https://ibapac.tlabs.ac.za/application-form/