

About the Laboratory

The Tandem Laboratory is a world-leading facility in ion beam-based materials analysis, functioning as an independent centre within Uppsala University. As a national research infrastructure it provides access to accelerators for both academic researchers and industry partners. The director is responsible for the laboratory's daily operations, while its board consists of representatives from academia and industry.

Following a decision by the Swedish parliament in 1965 a national accelerator research centre was established in Uppsala. Throughout its history, the laboratory's equipment has been continuously redesigned and improved. Focus has shifted from fundamental research in nuclear physics to applications in technology, life sciences, and materials research.

UPPSALA 2025. Foto: M. Kamsten, D. Primetzhofer, I. Bergström, S. Lohmann, A. Castenson



Our Services

Our services in ion beam analysis (IBA) and ion beam modification of materials (IBMM), as well as accelerator mass spectrometry (AMS), are requested each year by hundreds of users.

- Characterisation of material composition and structure at the nanometre scale, without sample destruction
- Tailor-made material modification at the nanometre scale to adjust material properties
- Ultra-sensitive mass spectrometry and radiocarbon dating

Contact

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Radiocarbon dating: radiocarbon@physics.uu.se

We are located at the Ångström Laboratory in Uppsala

Tandem Laboratory

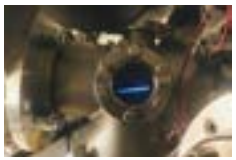
A National Research Infrastructure

Ion Beams for Science and Society

The Tandem Laboratory provides access to particle accelerators for the analysis and modification of materials at the atomic scale

UPPSALA UNIVERSITET









Applications in Materials Analysis

High-precision radiocarbon dating

In our radiocarbon laboratory, we are able to determine the age of materials with high precision using accelerator mass spectrometry (AMS). Very small quantities are sufficient for analysis, down to a few micrograms of carbon.

Radiocarbon dating is a well-established tool in research fields such as cultural heritage, archaeology, and geology, but it is also used in medical research, for example, to determine the lifespan of cells. Age determination using radiocarbon is further applied in art authentication and forensic science.

Ion Beam Analysis (IBA) and Modification (IBMM)

Our accelerators are used for Ion Beam Analysis (IBA) and Ion Beam Modification of Materials (IBMM) in both fundamental research and practical applications across industry and society.

As an example, moon dust from Apollo 16 has been analysed to study the solar wind, and plasma-exposed materials have been examined to understand the durability of fusion reactors. In the medical field, titanium particles from dental implants have been detected in gum tissue using accelerator-assisted microscopy (micro-PIXE), providing information useful for investigating the correlation between particle concentration and inflammation-related gene expression. When developing new energy materials, ion beam-based analysis provides crucial information – for example, how elemental distributions in materials for photochromic windows and solar cells can affect their properties. Mechanical components such as engines require hard surface coatings, which are also studied at the laboratory.

Particle accelerator platforms are likewise used to tailor materials at the atomic level through targeted ion implantations, as in the production of microchips or nanostructured materials.

Accelerators

5 MV Pelletron Tandem Accelerator

The Tandem Accelerator, the largest accelerator in the laboratory, supplies a wide spectrum of light and heavy ions with energies ranging from 1 to 50 MeV. The ions can be directed to six experimental setups for various applications in ion beam analysis and materials modification.

350 kV Ion Implanter Accelerator platform

Our ion implanter platform can generate keV ion beams from nearly all elements in the periodic table. Currents of up to a few mA enable high-dose implantations even on large sample areas. The system also serves as an ion source for low-energy ion beam analysis and for our unique *time-of-flight medium-energy ion scattering* system, allowing non-destructive, depth-resolved crystallography at the nanometre scale.

MICADAS – a Compact Tandem Accelerator

MICADAS is a compact tandem accelerator developed for ultra-sensitive mass spectrometry, primarily for radiocarbon dating. The instrument is equipped with permanent magnets reducing energy consumption and designed for efficient handling of different sample types.

Time-of-flight low-energy ion scattering

Low ion energies, below 10 keV, allow us to study the outermost atomic layer of solid materials using *time-of-flight low-energy ion scattering*. This accelerator platform is well suited for investigating processes such as oxidation or surface contamination, as well as issues related to thin-film technology and catalysis.

Smaller instruments supplement the accelerators, offering additional capabilities in sample preparation, analysis, and materials fabrication. Technical specifications for these, as well as for the accelerators, can be found on our website.

Emerging Technologies

The Tandem Laboratory's instrumentation is continually developed in order to incorporate additional analytical techniques. Currently, the laboratory is integrating X-ray-based materials analysis with ion beam-based analysis.

This initiative, called LigHt, is a platform for the analysis of light elements such as hydrogen and lithium, which are essential for carbon-free energy storage. LigHt will enhance the laboratory's complementarity to other major research infrastructures and open up new fields of research.

Education

The Tandem Laboratory continuously shares knowledge in materials analysis relevant to industry and society. We contribute to several undergraduate courses at Uppsala University, for example through student laboratory exercises using the tandem accelerator. We also provide user training for doctoral students and researchers throughout Sweden. We offer study visits for interested members of the public on request.

Funding and Collaboration

The Tandem Laboratory is supported by the Swedish Research Council. We also participate in several EU-funded projects within Horizon Europe, through which access to our facilities can be obtained via their transnational programmes. In addition, the Tandem Laboratory serves as a node within the fusion research programme EUROfusion.