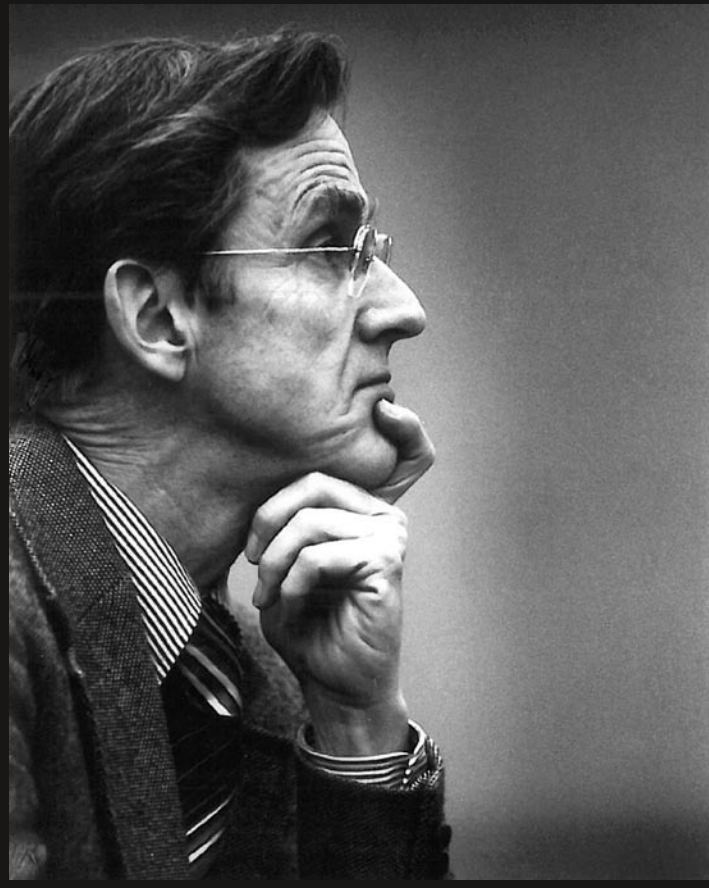


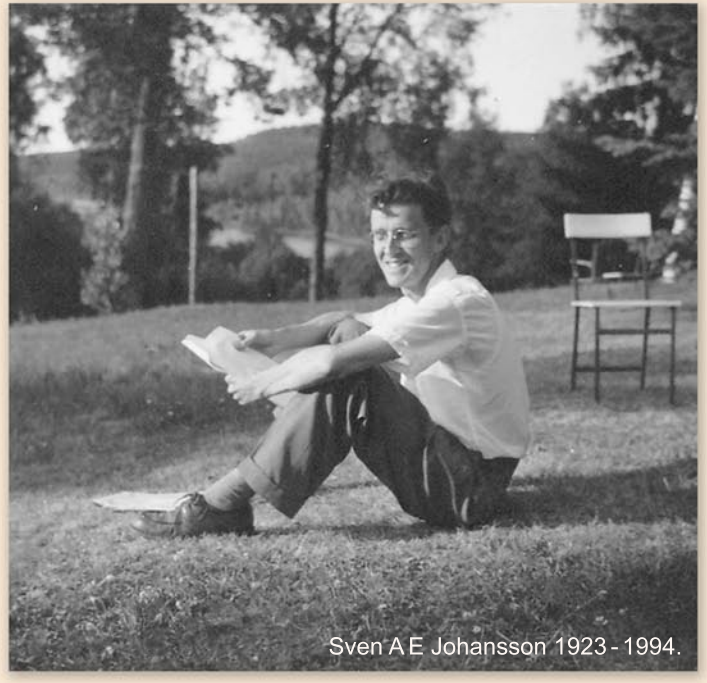
Sven Johansson and environmental physics

The chemical engineer who became a nuclear physicist, environmental physicist and Vice-chancellor of Lund University.

From chemistry to nuclear physics

Sven Johansson was born in 1923. After graduating from high school in Malmö, he studied chemical engineering at the Royal Institute of Technology (KTH) in Stockholm, and obtained his degree in 1944.

Like many other science students he was fascinated by modern physics, especially the new discoveries concerning the atomic nucleus. He therefore started his postgraduate studies at the newly established Division of Nuclear Physics in Lund.

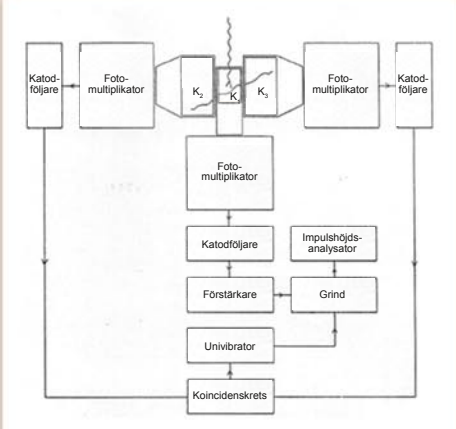


Sven A E Johansson 1923 - 1994.

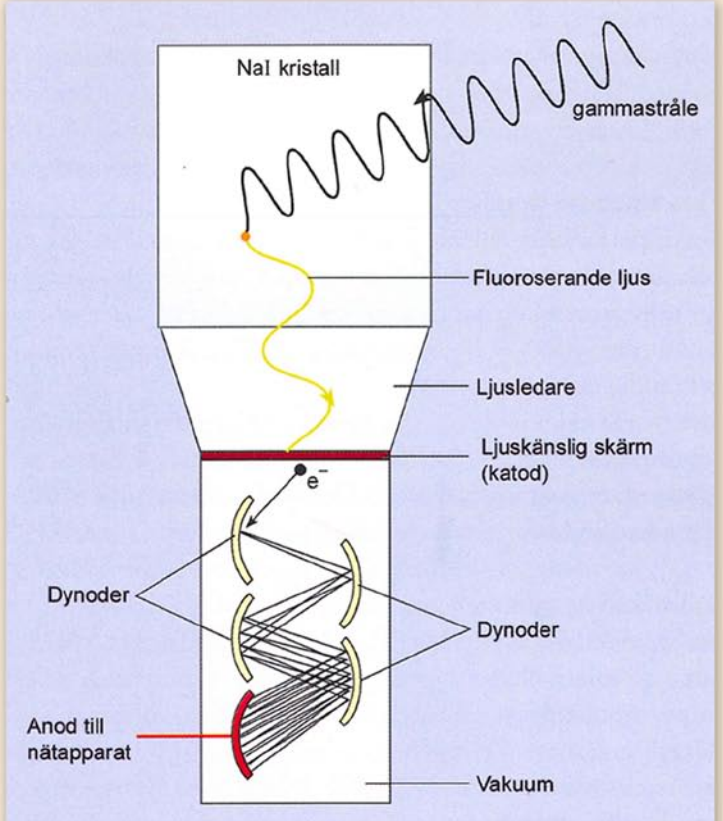
During a solar eclipse, when the face of the Sun is hidden, the corona remains visible – a shining area around the edge of the Sun.

Gamma spectroscopy

Sven Johansson obtained his doctorate in nuclear physics in 1952. In his thesis he described a new kind of gamma detector, a so-called scintillation detector using a NaI crystal as the detector material. He was one of the pioneers in this field, and developed the detector using the coincidence technique into the pair spectrometer, and quickly became internationally known.



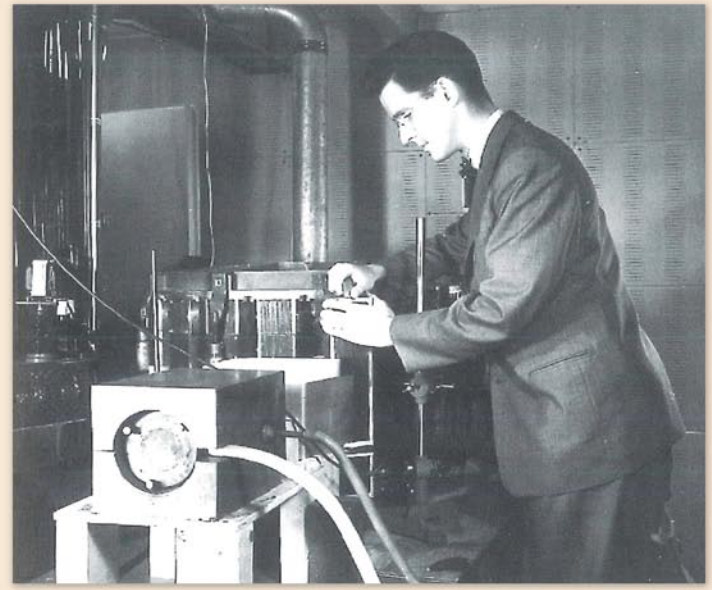
A pair spectrometer with 3 NaI Crystals.



Scintillation detector with NaI Crystals.

The 35 MeV synchrotron

In 1953, Sven Johansson worked at Iowa State College in the USA, where he conducted research using a 60 MeV electron accelerator. When he returned to Lund, the 35 MeV synchrotron built at KTH had just been installed, and experiments on photon-induced nuclear reactions, so-called photonuclear reactions, started immediately. The very first experiment, on the distribution of energy of photoprotons when the oxygen nucleus was irradiated, attracted considerable international interest.

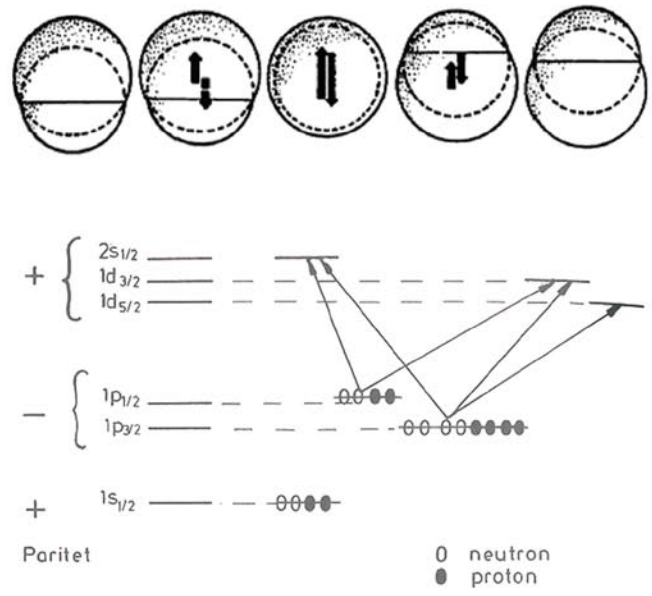


Sven Johansson at the 35 MeV synchrotron in Lund, showing the set-up used for the oxygen nucleus irradiation experiment in 1965.

The giant resonance

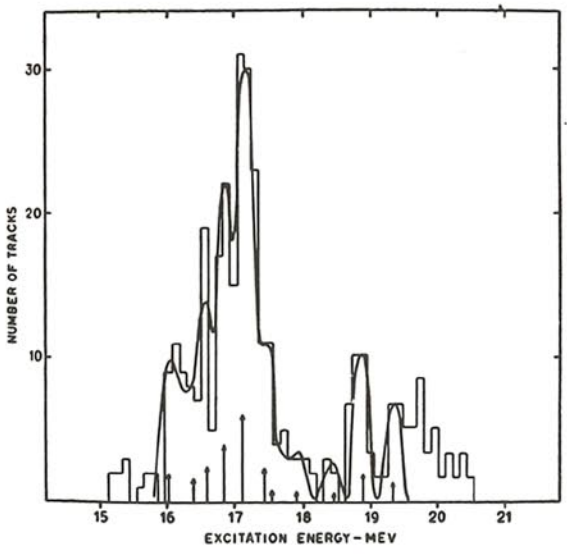
Atomic nuclei absorb gamma rays over a broad energy interval of 15 - 25 MeV. This is called the giant resonance. According to the liquid drop model for atomic nuclei, oscillations arise when groups of neutrons and protons vibrate against each other.

According to the shell model, the protons and neutrons in the nucleus move in discrete shells with defined quantum numbers. The giant resonance can also be explained with this model, but it was predicted to also have a fine structure. This was exactly what the experiment in Lund demonstrated.



A particle-hole transition according to the shell model.

The structure of the giant resonance



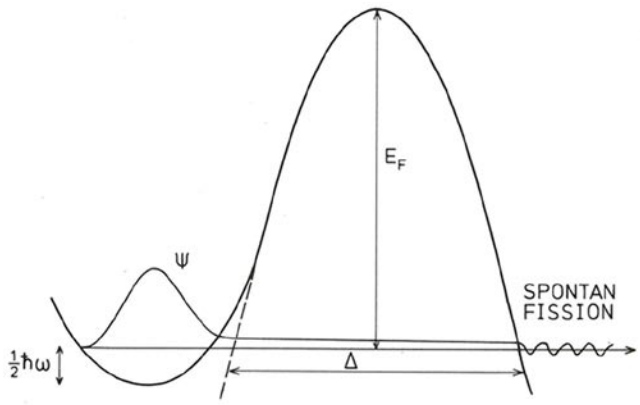
Spectrum showing the energy distribution of photoprotons from an oxygen molecule.

The oxygen nucleus (^{16}O) was irradiated with gamma rays from the synchrotron, causing it to become excited. Protons were emitted from the excited nucleus, and detected by the tracks made in photographic emulsions. The energies of the protons could then be determined from these tracks.

Not only did the energies of the protons agree with those predicted by theory, the angular distribution of the protons with specific energies was also in agreement with the shell model.

Fission and cosmology

Spontaneous fission



The wave function is leaking through the fission barriers and spontaneous fission occurs.

Sven Johansson also studied isotopes that undergo spontaneous fission, i.e. no extra energy is required to cause them to break up. He was one of the first to use Sven Gösta Nilsson's collective nuclear model to explain the process of fission. He also obtained good agreement between the model and experimental results. Together with his postgraduate student, Clas Otto Wene, he also suggested the existence of superheavy elements, an area of intense research by Sven Gösta Nilsson and his group in the 1960s.

Professor at LTH

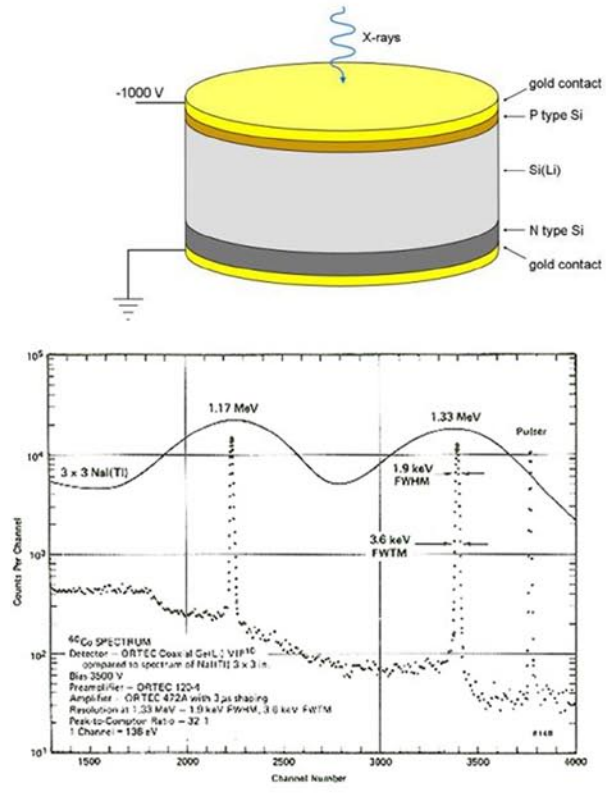
In 1965, Sven Johansson was appointed professor at the newly established Lund Institute of Technology (LTH). Apart from nuclear physics, the research at his division was soon to take a new direction. Together with his PhD students, Roland Akselsson and Thomas B Johansson, Sven developed a new analytical method called PIXE – Particle Induced X-ray Emission – based on his experience in nuclear physics.

Roland Akselsson, Sven Johansson and Thomas B Johansson.

PIXE

The X-rays emitted in PIXE were detected and their energy was measured using the newly developed semi-conductor detectors, which had a very high energy resolution. In normal X-ray analysis, the characteristic X-rays emitted by atoms when they are excited with high-energy electrons or broadband X-ray radiation, are measured.

Sven Johansson and his colleagues used protons from a Pelletron accelerator for excitation. In this way, they were able to avoid the high background radiation from excited electrons and gamma rays. The detection limit was reduced by a factor of 1 000.

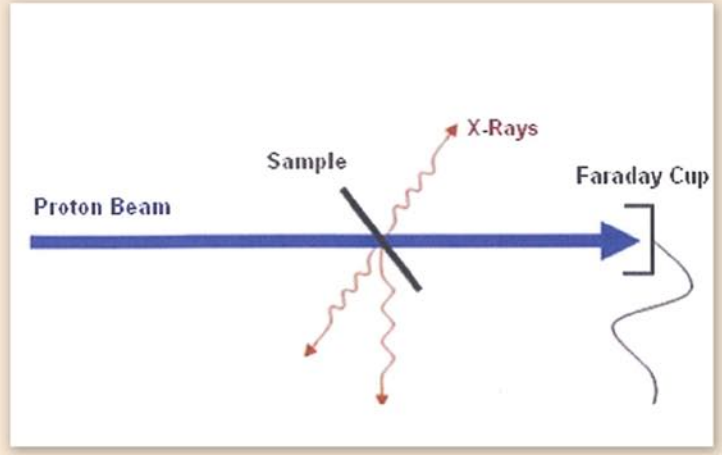


Comparison between the energy resolution of a NaI detector and a semiconductor Ge(Li) detector.

Characteristic X-rays

High-energy particles or X-rays can knock out an electron from an inner orbit in an atom. When the hole is filled by an electron from an outer orbit, a photon is emitted with a wavelength that is characteristic of that atom.

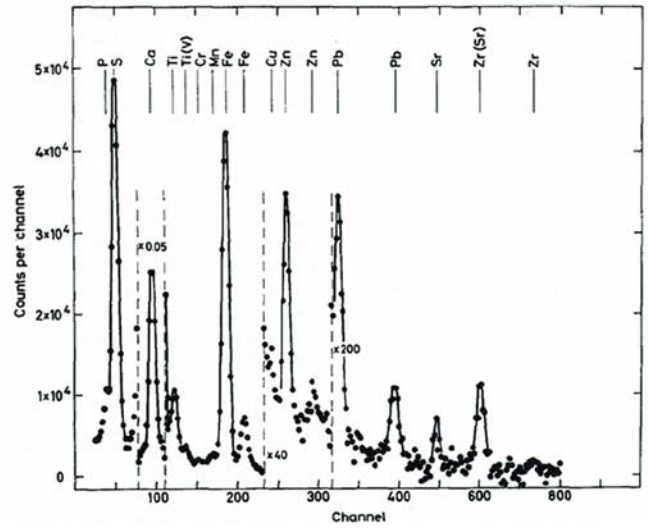
These were the wavelengths measured with high precision by Manne Siegbahn at the Department of Physics a hundred years ago. Using high-resolution Si(Li) detectors it is possible to determine the amounts of different elements in the same experiment. The low background in PIXE measurements allows the determination of levels as low as one part in 10^{-12} less than the sample.



Environmental applications

By the beginning of the 1970s environmental problems such as acidification and air pollution had been identified.

The PIXE method was soon found to be suitable for the analysis of particles in the air (aerosols) collected on thin filters. At the same time, Sven Johansson was elected Vice-chancellor of Lund University and it was he who initiated the multidisciplinary *Environmental Management Programme*, in which knowledge and methods relevant for the understanding of the negative effects of transport and energy production on the environment were collected.

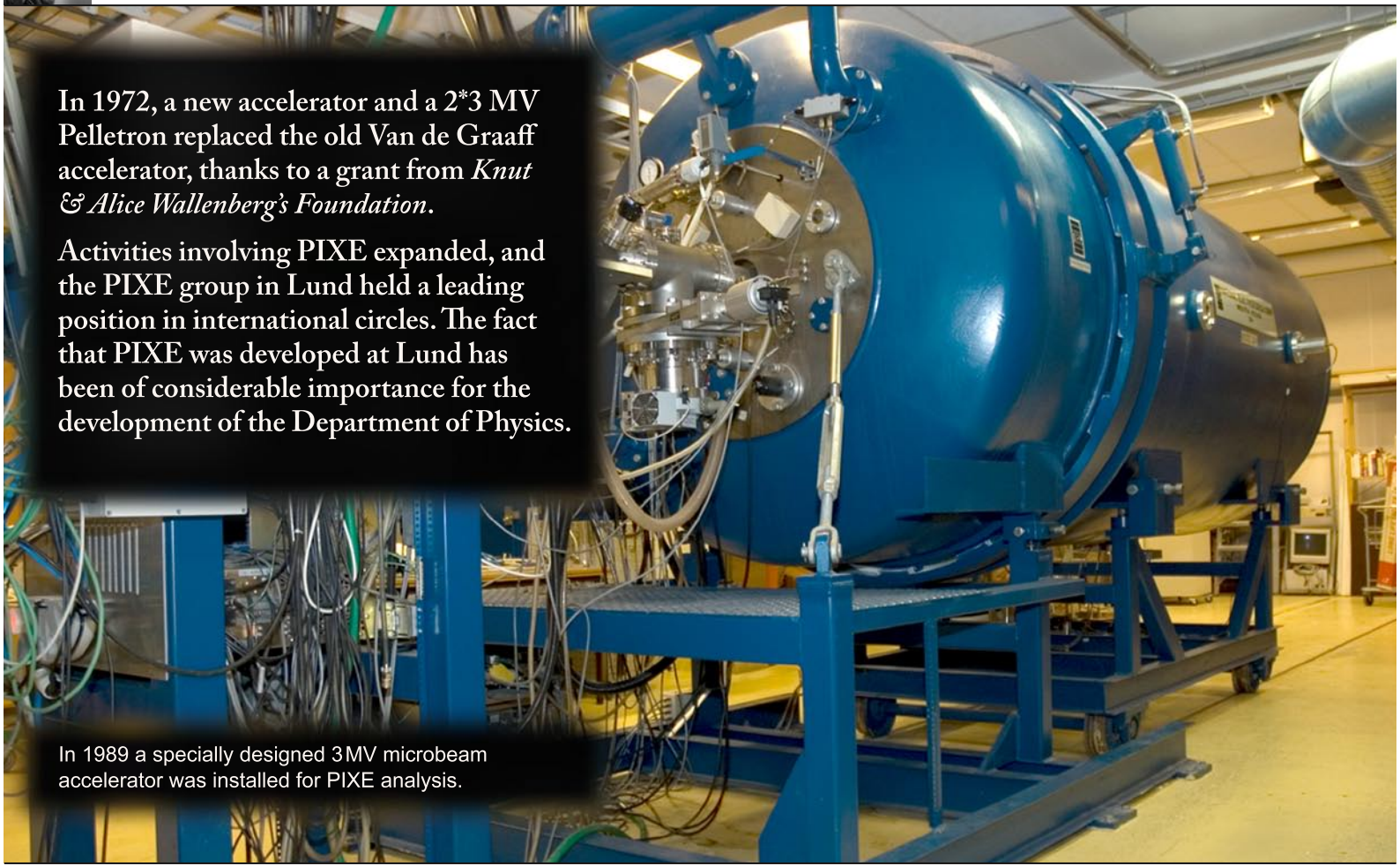


The spectrum obtained from matter deposited on a carbon foil left outdoors for one day shows the presence of significant amounts of sulphur and calcium, as well as zinc and lead, in the air we breath. Both K and L X-rays can be seen.

New accelerators

In 1972, a new accelerator and a 2*3 MV Pelletron replaced the old Van de Graaff accelerator, thanks to a grant from *Knut & Alice Wallenberg's Foundation*.

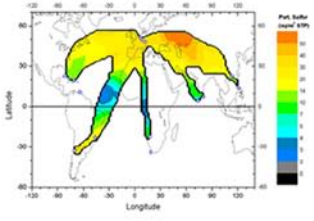
Activities involving PIXE expanded, and the PIXE group in Lund held a leading position in international circles. The fact that PIXE was developed at Lund has been of considerable importance for the development of the Department of Physics.



In 1989 a specially designed 3 MV microbeam accelerator was installed for PIXE analysis.

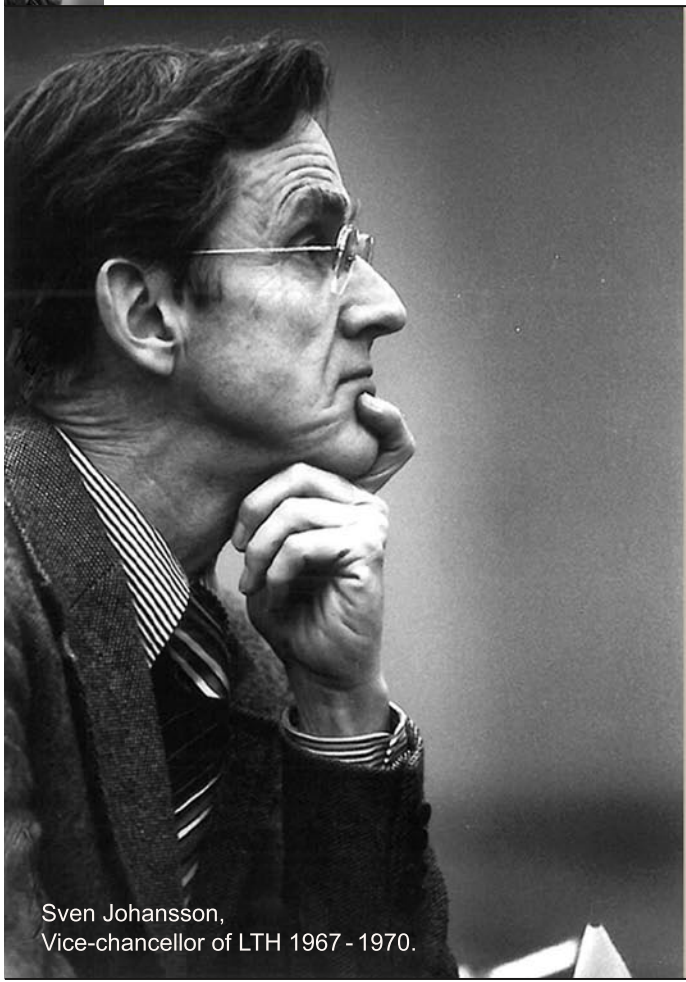
PIXE experiments with participants from Lund

Tycho Brahe was a famous astronomer in the second half of the 16th century. When his tomb was opened in 1966, samples of hair from his beard showed high levels of mercury, indicating that he may have been poisoned. New samples were taken and analysed in 2010, which did not support this theory. Jan Pallon from the Department of Physics in Lund was a member of the team taking part in this study.



Research groups from six countries, including Bengt Martinsson from Lund, have together studied trace gases in the troposphere and stratosphere in an attempt to understand environmental atmospheric processes. Aeroplanes were equipped with measuring equipment allowing a large-scale study to be conducted on aerosols at these high altitudes.

The leader



Sven Johansson,
Vice-chancellor of LTH 1967 - 1970.

After only four years in Lund, Sven Johansson won his colleagues' respect and was elected Vice-chancellor of LTH in 1967.

When it was later decided that LTH should become the Engineering Faculty of Lund University in 1970, the professors at LTH demanded that elections should be held for the position of Vice-chancellor of the University, and Sven was proposed as a most suitable candidate.

Rector Magnificus

The 1960s were characterised by student unrest in the Western world, and this reached its climax in Lund on 28 February 1969. During a meeting between representatives from industry and the University, students took over the lectern and turmoil broke out. In the end, the meeting had to be abandoned.

When electing a new Vice-chancellor of the University a year later, many believed Sven Johansson to be the right person to bring about reconciliation between teachers and students.

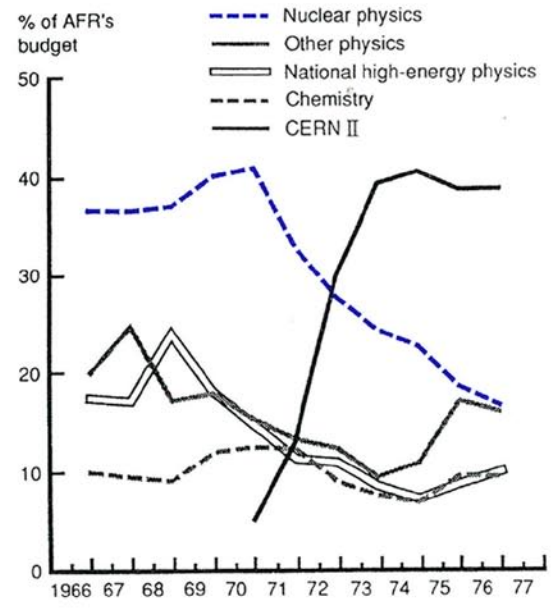
Sven Johansson,
Vice-chancellor of Lund University 1970 - 1977.

Research politics

Sven Johansson made important contributions to Physics in the Royal Swedish Academy of Sciences (KVA), and chaired the Nobel Committee for several years.

Sven was a staunch supporter of small successful research groups, and believed that large projects attracted so much funding, both nationally and internationally, that creativity in research suffered.

It was for this reason that he abstained when the Swedish Atomic Research Council (AFR) voted to support the expansion of CERN in 1971. He claimed it was a political decision, rather than a research decision.



Distribution of government funds to various areas of physics, chemistry and CERN-based particle physics from 1966 to 1976.

When Sven Johansson wasn't working, which he did almost all the time, he could be found with a book in his hand, or listening to classical music.

If he had any time over, he liked to drive big American cars or play tennis.

Sven Johansson together with his wife Aina, at the beginning of the 1950s.