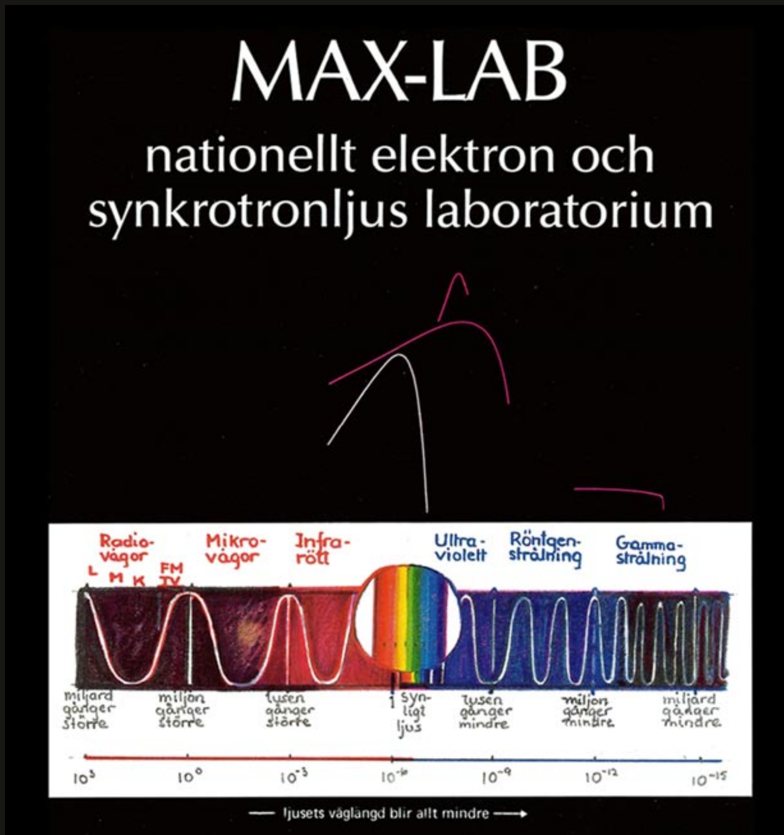


”Lord of the Rings”

The story of baby MAX
– how he learned to walk
and grew up to be big and strong.

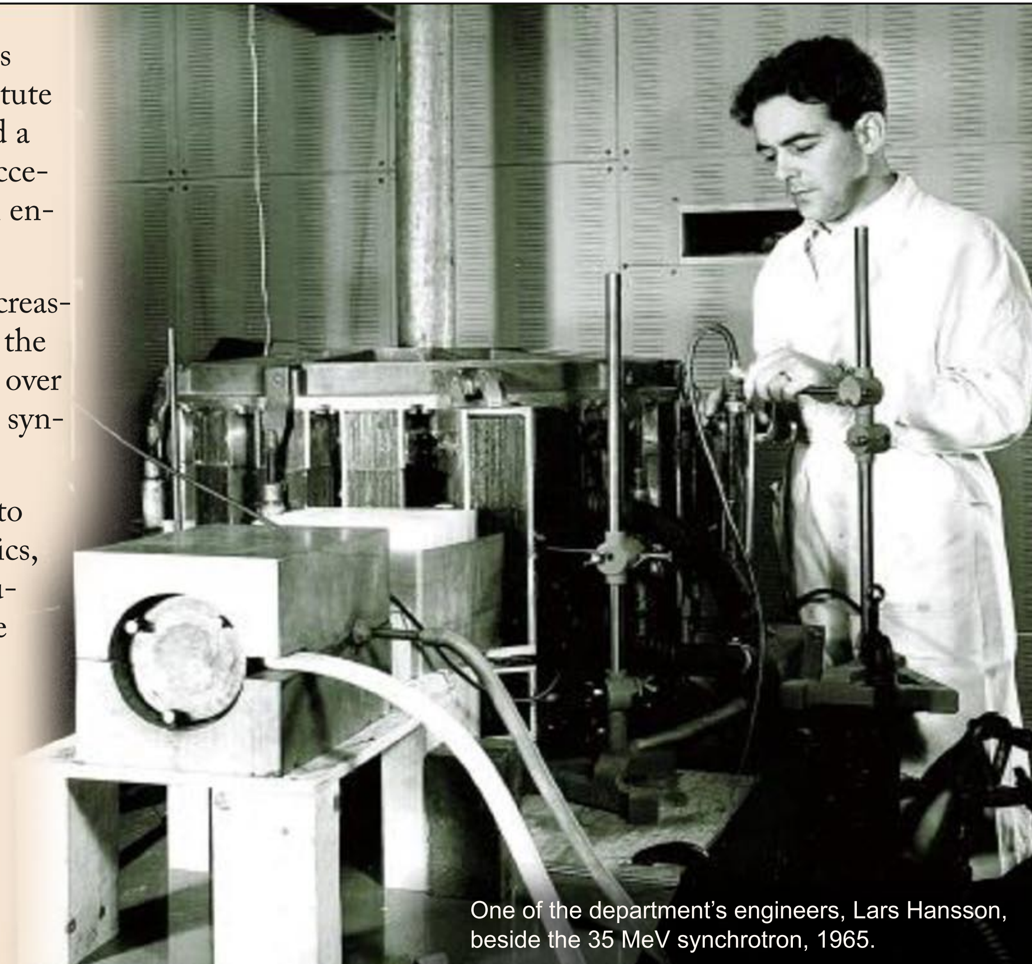
A small ring

Sweden's first electron accelerator was built in Stockholm at the Royal Institute of Technology, KTH, in 1945. It had a diameter of 13 cm, and was able to accelerate electrons in circular path, to an energy of 2 MeV.

Its designer, Olle Wernholm, built increasingly larger accelerators, and in 1953, the Department of Physics in Lund took over his latest creation, a 35 MeV electron synchrotron.

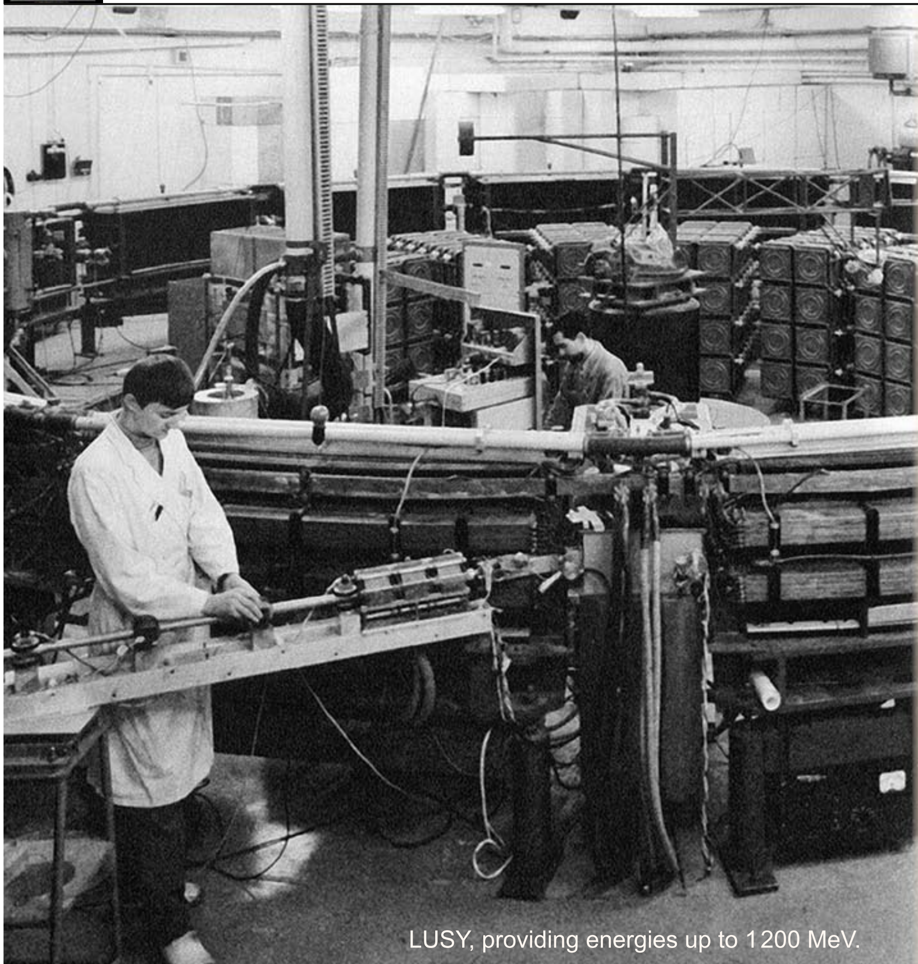
Kurt Lidén, assistant professor, later to become a professor in radiation physics, and Sten von Friesen, professor in nuclear physics, were responsible for the accelerator being located in Lund.

> 1 MeV is the energy of an electron when it is accelerated by a potential of 1 million volts.



One of the department's engineers, Lars Hansson, beside the 35 MeV synchrotron, 1965.

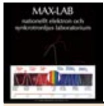
A larger ring



LUSY, providing energies up to 1200 MeV.

The 35 MeV synchrotron was used for experimental nuclear physics. After a while, there was a need for higher energies to study mesons and other newly discovered particles.

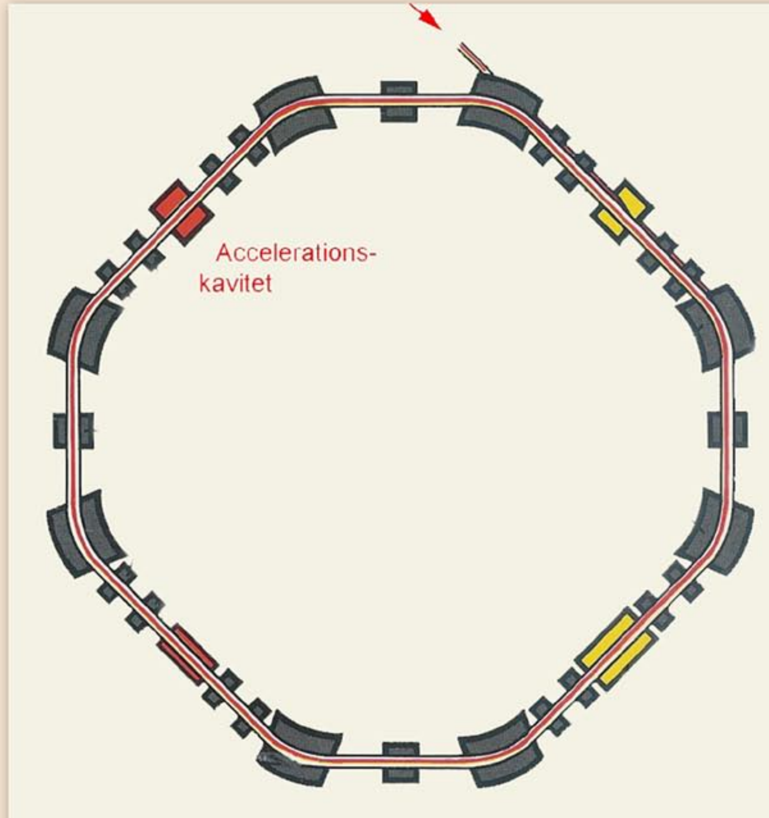
Olle Wernholm had plans for a larger synchrotron. The question was whether it would be located in Lund or Uppsala. Thanks to Sten von Friesen, a number of companies in the region provided funding for a building in Lund to house the accelerator – where it was placed. The accelerator was called LUSY – the Lund University Synchrotron.

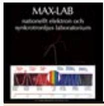


The principle of the synchrotron

Electrons are accelerated by an electric field, and are then injected into a circular accelerator. Their energy is increased with every revolution in the system by regions with a high-frequency electric field, which are synchronized with the period of revolution, hence the name synchrotron.

The radius of the electrons' path is determined by their velocity and the strength of the magnetic field bending them into a circular path. If the velocity of the electrons entering the ring is close to the speed of light, the extra energy they gain increases their mass instead of their velocity, and the electrons remain in the circular path.

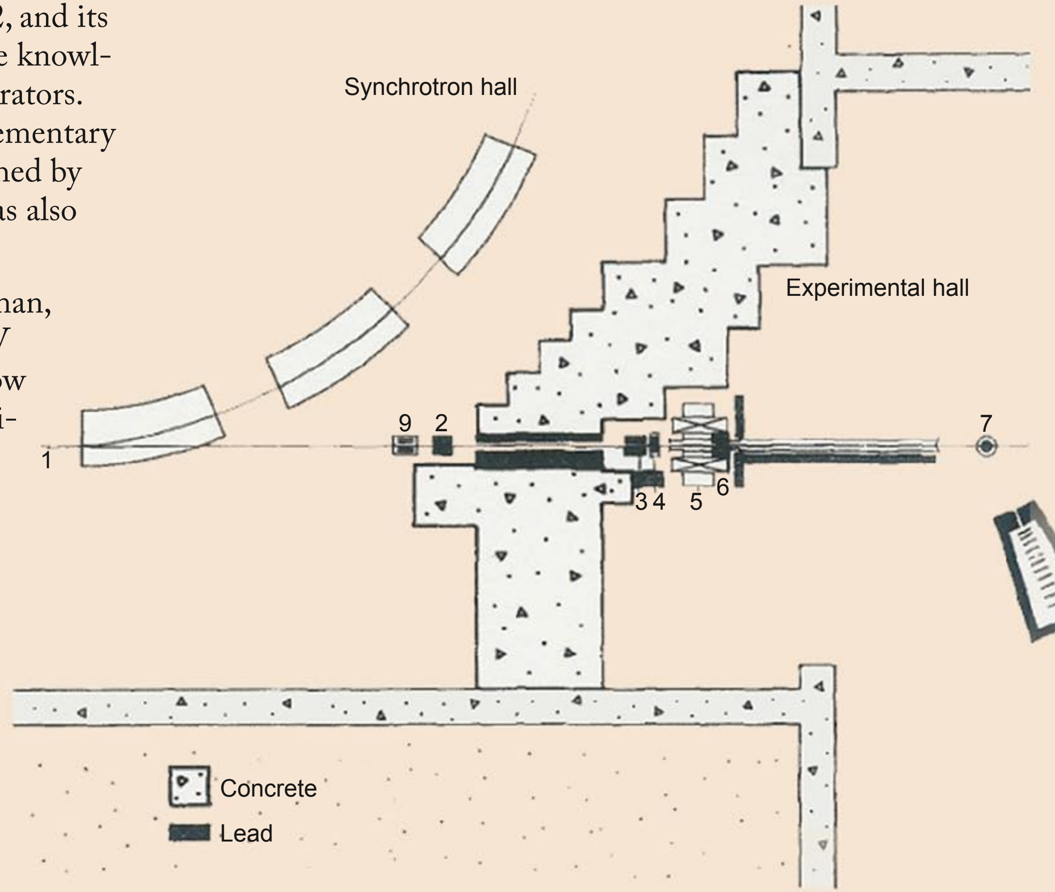




Research at LUSY

LUSY came into operation in 1962, and its operators became increasingly more knowledgeable on the operation of accelerators. A new division for research into elementary particles, using LUSY, was established by Guy von Dardel in 1965. LUSY was also used to produce pi-mesons.

Another group, led by Bengt Forkman, was working with both the 35 MeV synchrotron and LUSY to study how the nucleus was affected by the radiation resulting from the collision of electrons with material.

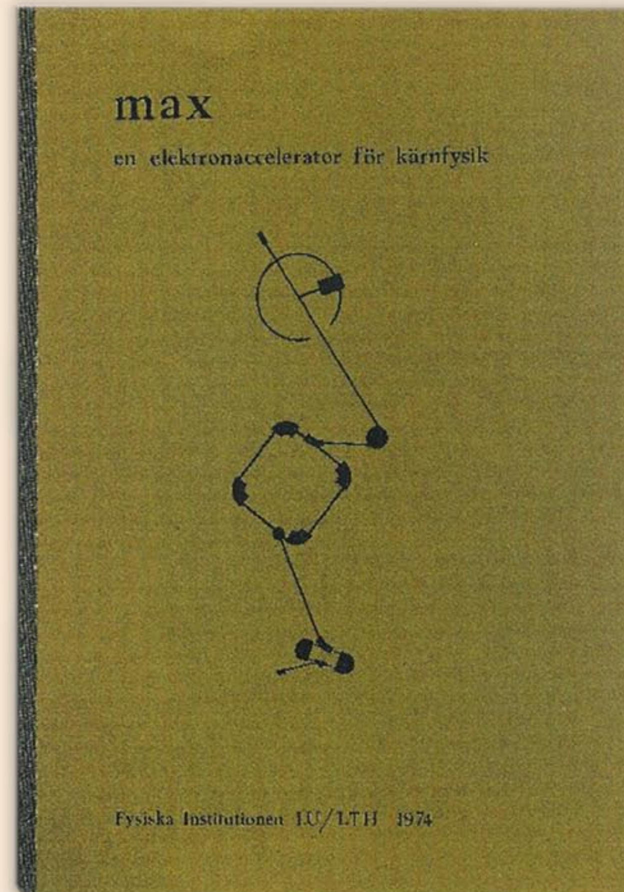


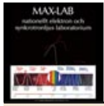
1971 – A fateful year

When discussions started on a major expansion of CERN (the European Organization for Nuclear Research, in Geneva), the question of Sweden's financial contribution to the project arose.

In 1971, it was decided that funds would be redirected from the grant for nuclear physics, and thus support for LUSY ceased.

The Accelerator Group and the Photonuclear Group had to take measures to save their activities in Lund. There was no lack of ideas, and an application to the Council for Atomic Research, signed by Bengt Forkman and the operational manager at LUSY, Rune Alvinsson, was completed at the beginning of 1974.





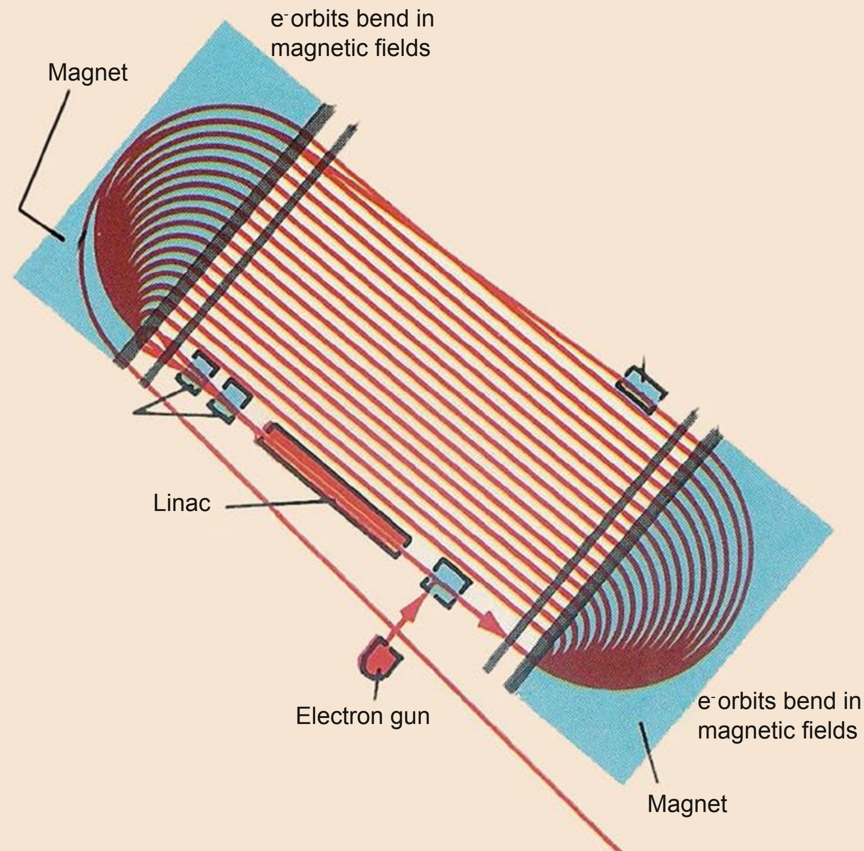
The origin of MAX

The new proposal was for a small facility for research in nuclear physics, consisting of an accelerator that could produce electrons with an energy of 100 MeV – a ring that could transform the short pulses from an accelerator to a continuous beam of electrons, and a system that could identify electrons with a specific energy for nuclear physics experiments.

The planned accelerator had been developed by Olle Wernholm, and was called a racetrack microtron, as the electrons moved in a path similar to a racetrack.

> The name of the new accelerator, MAX, is derived from Microtron, Accelerator, and the fact that the circulating electrons emit X-rays.

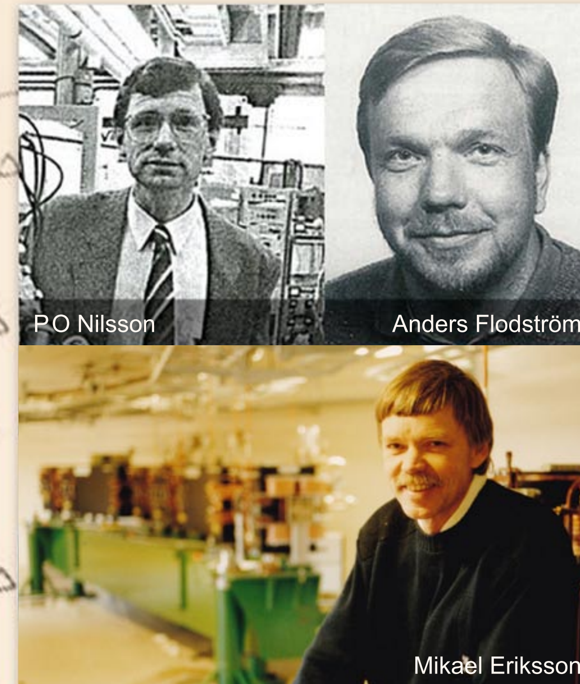
100 MeV Microtron



A bright idea

Initially, it was intended that the MAX project would involve only nuclear physics, but researchers in material physics, P O Nilsson from Gothenburg and Anders Flodström in Linköping, suggested early on that perhaps MAX could be used to produce synchrotron radiation.

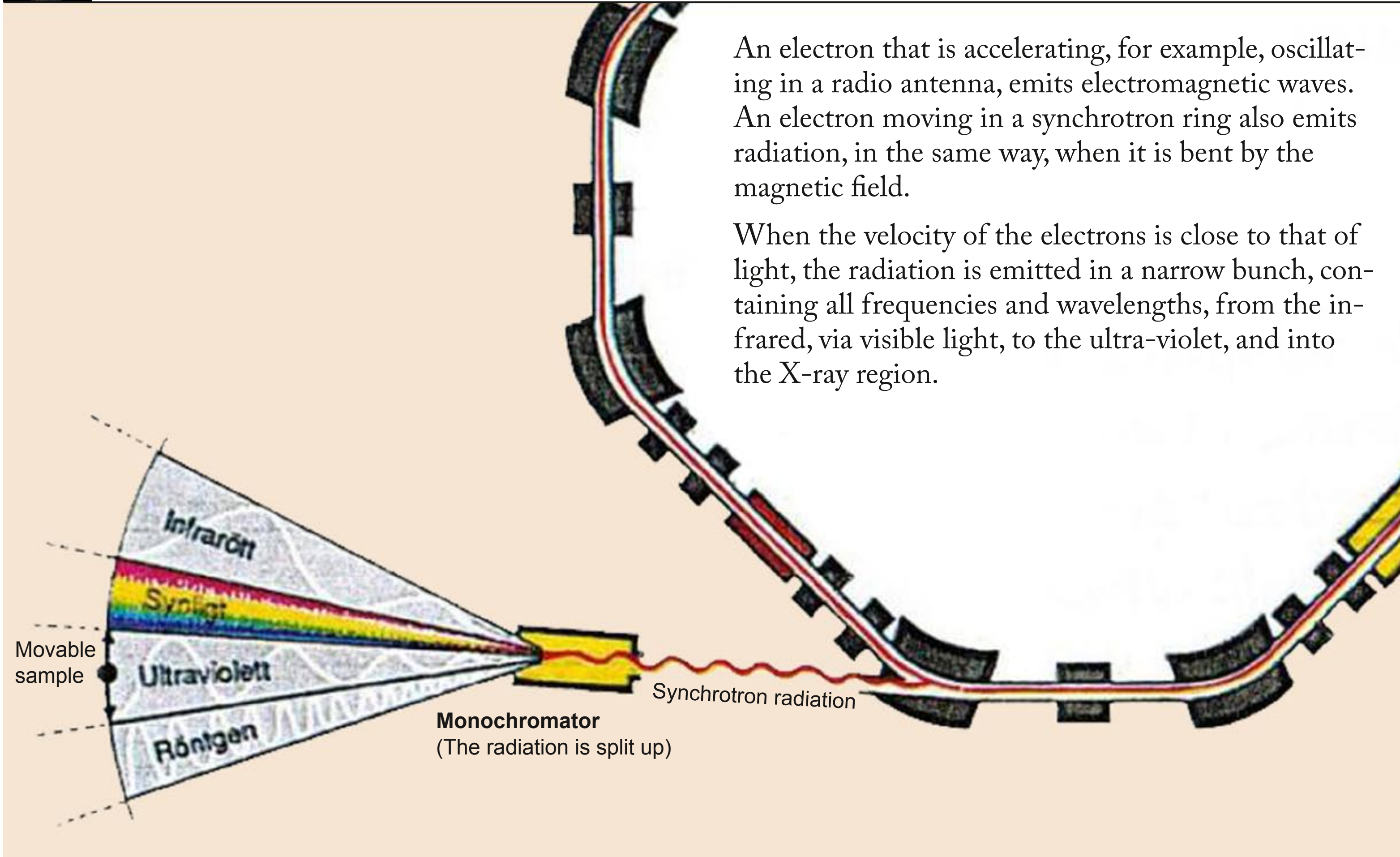
Mikael Eriksson, who had been the technical director of MAX-lab since the beginning, investigated this possibility, and the MAX project was expanded to include research using synchrotron radiation. The storage ring was designed to increase the energy of the electrons to 550 MeV.



Synchrotron radiation

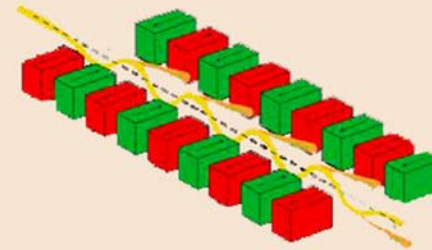
An electron that is accelerating, for example, oscillating in a radio antenna, emits electromagnetic waves. An electron moving in a synchrotron ring also emits radiation, in the same way, when it is bent by the magnetic field.

When the velocity of the electrons is close to that of light, the radiation is emitted in a narrow bunch, containing all frequencies and wavelengths, from the infrared, via visible light, to the ultra-violet, and into the X-ray region.



Undulators

Undulator from MAX III.

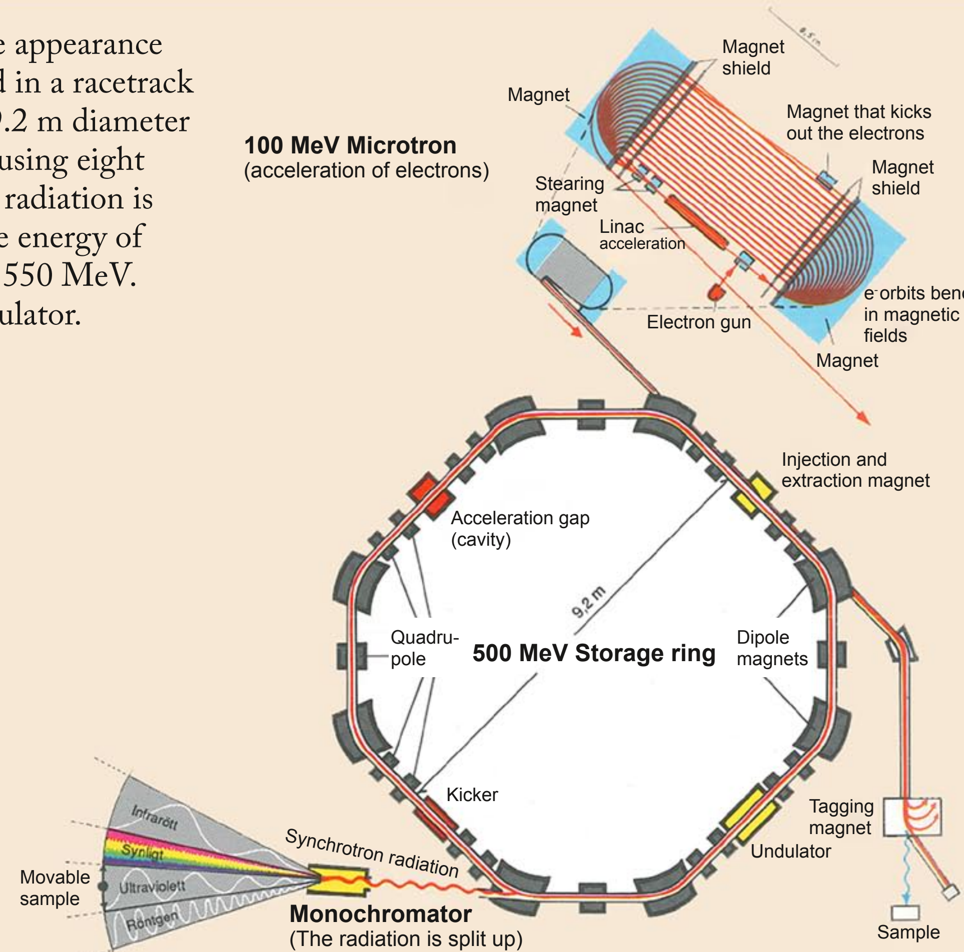


The fact that synchrotron radiation has a high intensity over an extremely broad frequency range makes it useful in widely varying areas of research.

The intensity of the radiation can be increased using an undulator, in which the electrons pass through a magnetic field with alternating polarity. This will cause the electrons to oscillate, emitting radiation from each undulation.

When the distance between the magnets is suitably adjusted, the radiation will interfere, leading to higher intensity in a narrow frequency interval.

This change in plans led to a change in the appearance of MAX. The electrons are first accelerated in a racetrack microtron, before being injected into the 9.2 m diameter storage ring. The circular path is obtained using eight magnets, and every time the beam is bent, radiation is emitted. Along a small part of the ring, the energy of the electrons is increased to its maximum: 550 MeV. In another part of the ring there is an undulator.

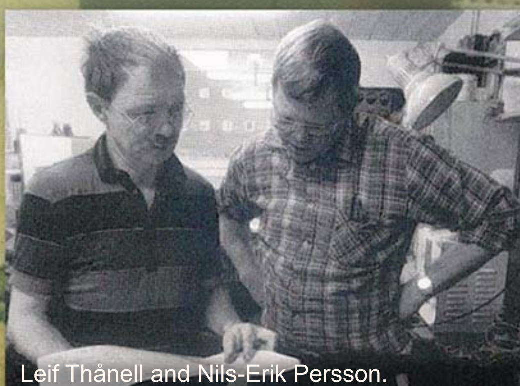


Experimental nuclear physics was performed, up until spring 2015, in a separate laboratory using electrons from the ring.

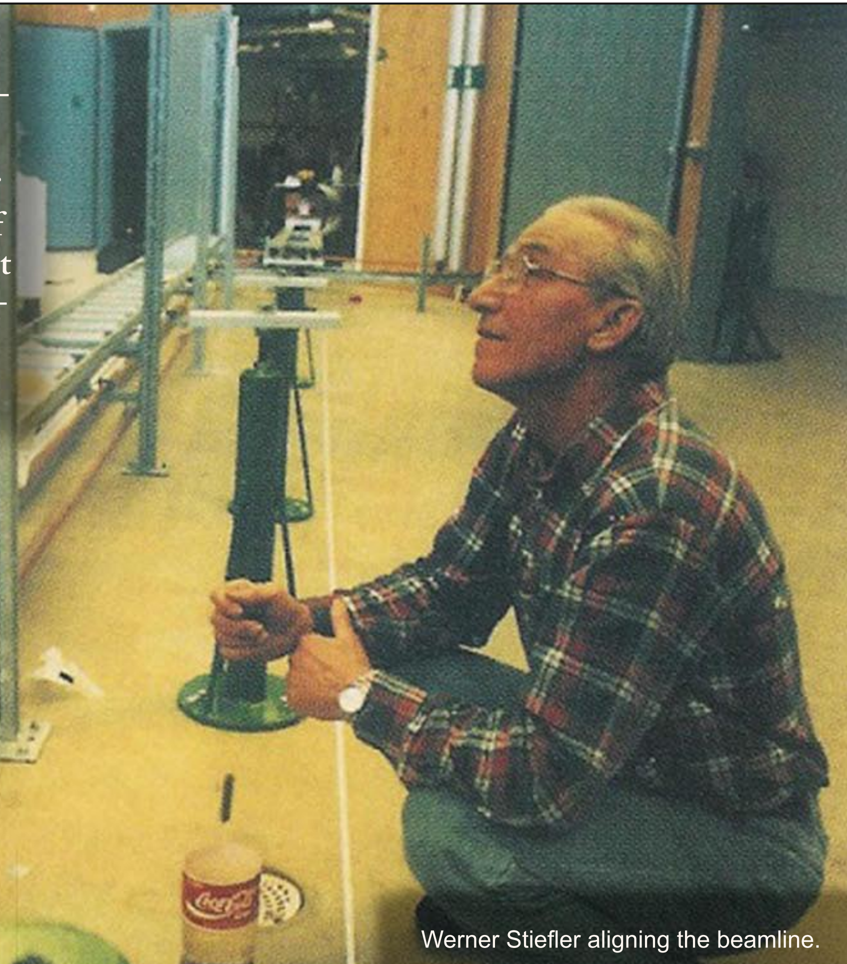
Do-it-yourself

In order to reduce the cost of the project, and to ensure a high degree of flexibility, most of the components for MAX were constructed originally at the Department of Physics, and later at MAX-lab.

This was possible thanks to ten years' experience of running and refurbishing LUSY. The entire project was led by Bengt Forkman, together with the technical director, Mikael Eriksson, and Leif Thånell, who was head of engineering.



Leif Thånell and Nils-Erik Persson.
An ordinary group of Swedish technicians, dedicated and loyal to the task, built MAX-lab.



Werner Stiefler aligning the beamline.

MAX leaves home!

Sensational news! MAX-lab moves into new premises at LTH. *It will be a great success*, says Bengt Forkman.

The large photo shows the same place ten years later.

In 1981, MAX-lab became an independent research facility, with its own board and director. The main reason for this was to promote it as a national laboratory.

At about the same time, The Swedish Scientific Research Council (NFR) decided to make research with synchrotron radiation an area of high priority. This idea was embraced by Lund University, and a large experimental hall at the Faculty of Engineering (LTH) was made available for the accelerator.

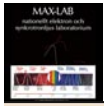
MAX grows up

MAX II was inaugurated on 15th September 1995 by the Swedish King Carl XVI Gustaf.

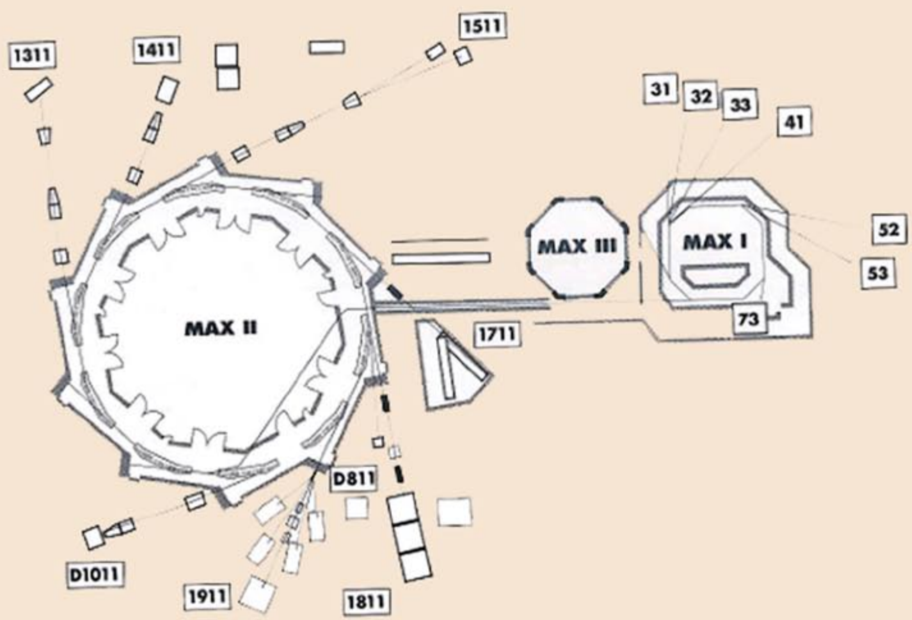
Ingolf Lindau, the director from 1991 to 1997, can be seen here together with the King.

Even before MAX started to produce synchrotron radiation in 1986, Mikael Eriksson and Anders Flodström had started to plan the further development of MAX to produce higher energies, and thus greater intensities and shorter wavelengths. In 1991 the NFR decided to support a project to build a 30 m diameter ring, producing energies of up to 1 500 MeV. The project was called MAX II.

The new project required even larger premises, and the new 4 000 m^2 building was completed in February 1993.



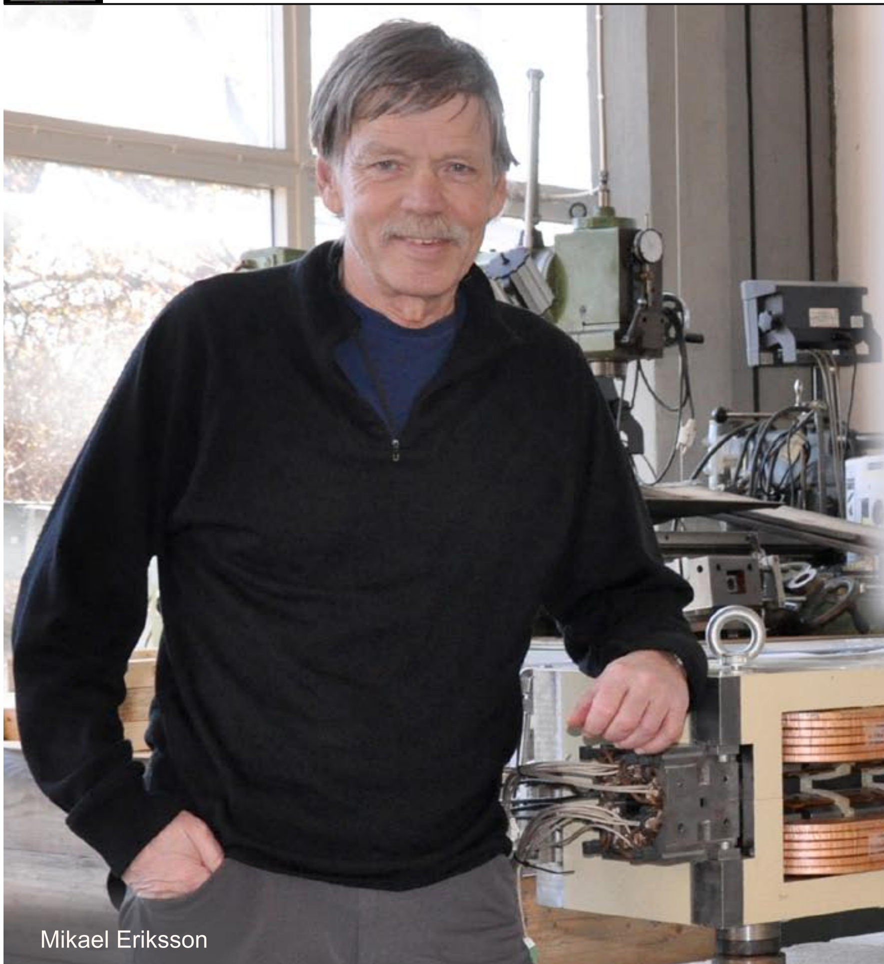
MAX-lab



The accelerators at MAX-lab consisted of three electron storage rings (MAX I, MAX II and MAX III) and a pre-acceleration stage (MAX injector). MAX III was a 700 MeV ring built in 2007 to relieve user pressure on MAX II. It was also being used to test new technology in the construction of MAX IV.

All three rings produced synchrotron radiation for experiments and measurements in various areas of research in, for example, physics, chemistry, materials science, biochemistry and medicine, and were used by research groups from many countries.

The rings construction



Mikael Eriksson

Mikael Eriksson, the designer of MAX, started his career as a PhD student in the Photonuclear research group, and soon became interested in the development of accelerators.

MAX-lab's consultant Bengt Anderberg from Scanditronics designed the injector system and shaped the magnets directly from the massive iron plates. This compact magnetic structure resulted in significant benefits, not least cost-wise.

Mikael's pioneering work has earned him the highest international recognition. He is regarded as a pioneer in accelerator physics, and new synchrotrons are based on his ideas.

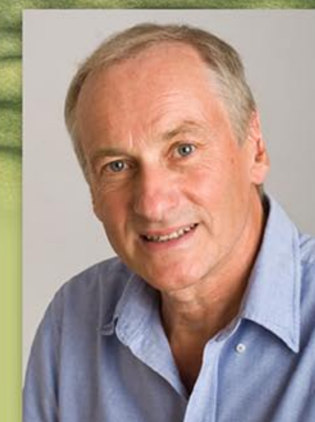
Bengt Anderberg

The future of MAX

MAX IV was inaugurated 21st of June 2016.

MAX-lab was created thanks to physicists from outside Lund and the management of Lund University. This was complemented by the bold and skilful planning and knowledgeable contributions of the MAX Group.

Research at MAX IV is important in finding new materials in a world of ever-dwindling resources, and to broaden our knowledge in biophysics and chemistry, as well as to test new theories and experimental techniques.



Nils Mårtensson, director of MAX-lab from 1997 to 2011, has guided the MAX IV project around many obstacles, and has succeeded in taking it from conception to reality.