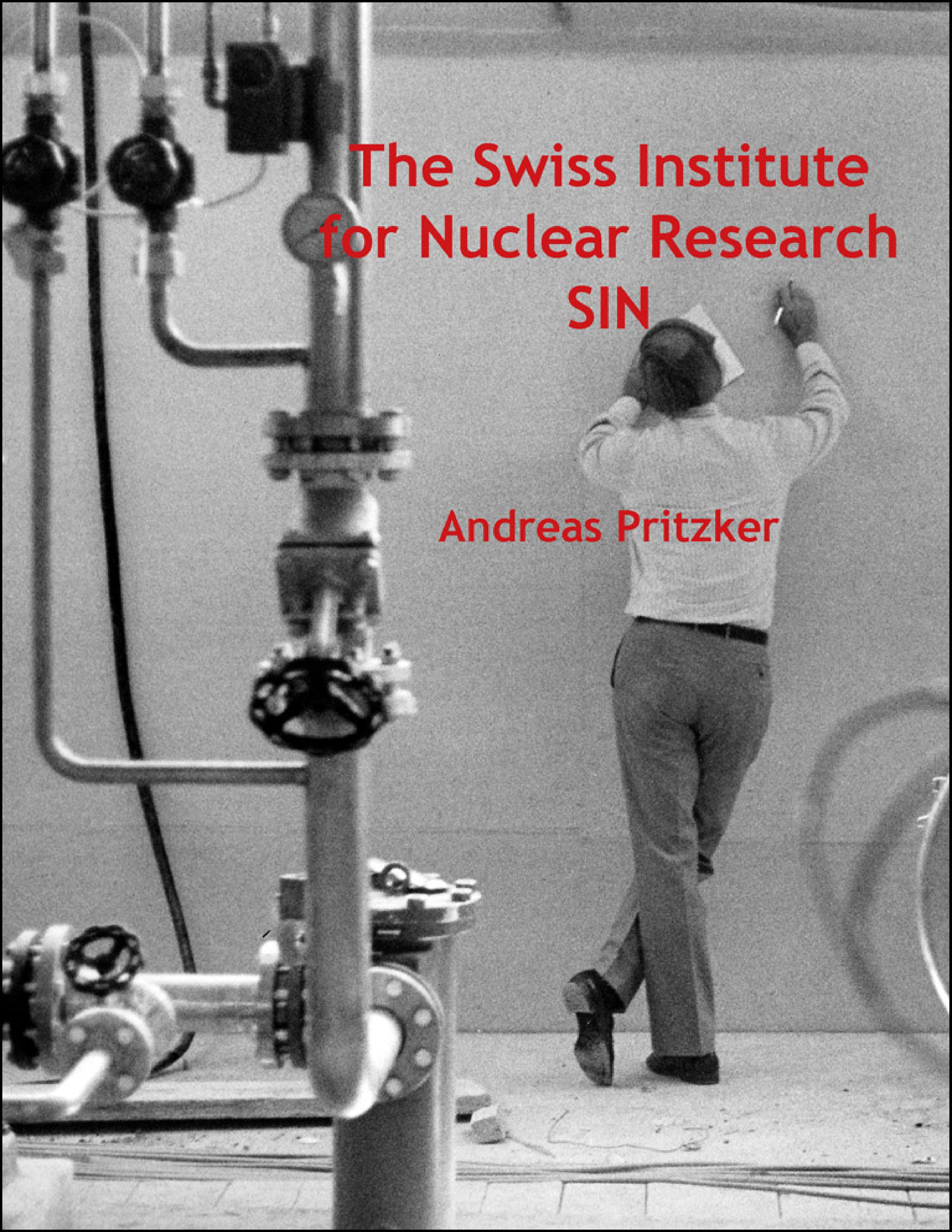

The Swiss Institute for Nuclear Research SIN

Andreas Pritzker

This book tells the story of the Swiss Institute for Nuclear Research (SIN). The institute was founded in 1968 and became part of the Paul Scherrer Institute (PSI) in 1988. Its founding occurred at a time when physics was generally considered the key discipline for technological and social development. This step was unusual for a small country like Switzerland and showed courage and foresight. Equally unusual were the accomplishments of SIN, compared with similar institutes in the rest of the world, as well as its influence on Swiss, and partially also on international politics of science.

That this story is now available in a widely understandable form is due to the efforts of some physicists, who took the initiative as long as contemporary witnesses could still be questioned. As is usually the case, official documents always show just an excerpt of what really happened. An intimate portrayal of people who contributed to success requires personal memories. This text relies on both sources. In addition, the events are illustrated with numerous photos.

Andreas Pritzker was born in 1945 in Windisch (Switzerland). After completing his studies in physics at ETH Zurich, he began working as a researcher and consulting engineer in the private sector, and then as researcher for the Swiss Institute for Nuclear Research (SIN). After five years working on the staff of the ETH Board, he became a member of the management of the Paul Scherrer Institute in 1988, first as head of administration and later of logistics. Since 2003 he has been active as a freelance author and publicist. He is married and lives in Küttigen (Switzerland).

In addition to his contributions to anthologies, his novels *Filberts Verhängnis* (1990), *Das Ende der Täuschung* (1993), *Die Anfechtungen des Juan Zinniker* (2007), *Allenthalben Lug und Trug* (2010), as well as his novella *Eingeholte Zeit* (2001) have been published. He was co-editor of the REFUNA AG story and editor of several historical texts.

For all who made SIN's success possible

Contents

Acknowledgments

In January 2012 Jean-Pierre Blaser invited me to a discussion meeting. Also present were Werner Joho and Urs Schryber who had taken the initiative to document the remarkable history of the Swiss Institute for Nuclear Research (SIN) while it was still possible to interview contemporary witnesses.

SIN was founded in 1968 as an annex-institute to the ETH Zurich and, together with the Swiss Institute for Reactor Research (EIR), became the Paul Scherrer Institute (PSI) in 1988. Jean-Pierre Blaser was the founder and only director of SIN. After having managed the project for the fusion of EIR and SIN, he became the first director of PSI. From the beginning, Werner Joho and Urs Schryber were involved as key physicists in the design and construction, and later the operation and upgrading, of the proton accelerators of SIN and PSI. Moreover, they developed the concepts of future large-scale facilities based on accelerators. I worked as a researcher at SIN from 1980 until 1983, and then on the staff of the ETH Board, responsible for the relations to the annex institutes. From 1988 until 2002 I managed first the administration, then the logistics at PSI.

The conversation during this first meeting revealed a plethora of information on SIN. This alone made it clear that SIN occupies an important position in the history of Swiss science.

During the year 2012 I gathered the necessary information on the history of SIN. My most important and most systematic source was their annual reports. In the beginning they were edited by Honorary Doctor A. Brunner, who was active as science editor and wrote broadly understood

articles for the Neue Zürcher Zeitung, for instance, about CERN and SIN. Simple in their design, these annual reports, nevertheless, communicate all important information regarding SIN.

Concerning the back story, I was able to rely on the documents created by Hermann Wäffler, Kurt Alder as well as Charles P. Enz et al. Jean-Pierre Blaser summarized important activities of SIN in notes and added amendments. Werner Joho and Erich Steiner helped develop this text and made personal experiences and photos available to me. Because Erich Steiner participated many years in the layout of experimental equipment – later he managed the high-current project and finally for PSI the large research facilities as well as the project spallation neutron source – Joho and Steiner represented the two main activities of SIN – accelerators and experimental facilities. Urs Schryber corrected and amended an early version of the manuscript. Ralph Eichler commented on the manuscript and supplied me with documents of the ETH Board's activities regarding the future of EIR and SIN (including the Hayek Study) as well as the B-Meson Factory. Additional documents regarding the Hayek Study were lent to me by Karsten Bugmann. In 2012, Dieter Brombach delivered to the PSI library precious and partially lost documents. Urs Brander, the manager of the PSI library, was very helpful in my search for documents. I received important tips and corrections regarding the entire manuscript from Christoph Tschalär and Wilfred Hirt, and from Eros Pedroni regarding the particle physics therapy.

General information was accessible to me on the Internet. Especially productive were the official publications of the Swiss Confederation, the Historic Lexicon of Switzerland as well as the knowledge portal of the ETH library in Zurich.

Photos were made available to me through the kind cooperation of PSI's photo library, Werner Joho, Erich Steiner and Jean-Pierre Blaser. Christa Markovits also contributed photos. Certain photos were taken from the annual reports of SIN. Some photos I was able to acquire from the ETH library. CERN as well as the Lawrence Berkeley National Laboratory made high-resolution photos available to me. I also found several photos on the Internet.

Retired secretary of state Heinrich Ursprung volunteered to describe his impressions of SIN in a preface – he accompanied the institute for years, as president of the ETH Zurich, and then as president of the ETH Board. Finally, Jean-Pierre Blaser summarized, in a personal retrospection, his overall view of SIN as well as his reflections on the politics of science, in addition to all his other information that became part of the manuscript.

The printing of the original German version of this book was financially supported by ETH Zurich and PSI Villigen.

My heartfelt thanks go to all who contributed to the success of this work.

Andreas Pritzker

Preface by Heinrich Ursprung

The planning and further development of universities are challenging tasks. They demand the consideration of a large time scale. If an existing course of study is to be eliminated, the brake length is measured in semesters; a little less for a Bachelor than a Master, a little more for a PhD. The addition of a new research field into the program demands the development of research course content and the projection of needed infrastructure. Since science policies cannot be carried out without scientists, sooner or later the question of (new) leaders arises.

The planning and further development of physics programs at ETH Zurich has taken place in exemplary fashion. In the 1950s, the step from nuclear physics to particle physics was in the air. CERN was founded on an international level. Advanced thinkers in various countries thought that physicists, who had prepared their experiments at home, would have access to the fantastic facilities and the immense experimental possibilities of CERN. Among Swiss physicists, Paul Scherrer was an early leader regarding the transition from nuclear physics to high-energy physics. As a theoretician, Res Jost recognized the potential of particle physics also in theoretical terms. And the president of the ETH Board, Hans Pallmann, professor of agricultural chemistry, had the strength of purpose to support the physicists' ambitious plans back in 1959. On the strength of his application, the Federal Council elected Professor Jean-Pierre Blaser as director.

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On October 1, 1973 I took over the presidency of the ETH Zurich. In this position I had the pleasure of meeting with SIN director Blaser on a regular basis, especially in the presidents' committee of the ETH Board. This panel, with its somewhat disparaging name, met under the direction of the president of the ETH Board and consisted of the presidents of both ETHs, Zurich and Lausanne, and the directors of the five research institutes active at that time. Everyone represented the interests of his own institute to the extent that they fell under the responsibilities of the ETH Board. For more than one and a half decades I witnessed the manner in which Blaser developed, managed and represented the creation and further development of SIN. His votes were mostly brief and always logical. As a fast thinker, he gave easily understandable responses to questions during discussions. Not all members of the panel possessed the same confidence based on background as he did; this sometimes led to tensions which never deterred him. The official languages during these sessions, as well as the ETH Board's plenum, were German and French, and Blaser had mastery of both.

I experienced discussions about SIN in a number of other committees, alone or with Blaser, in committees of the Swiss Parliament in preparation for parliamentary decisions, in work groups with Federal Offices in discussions over financial bills, in science policy committees. Often the question was raised whether SIN could fulfill its task as a user laboratory, or whether self-interest guided certain expansion plans. Such questions were usually raised, directly or indirectly, by university circles whose Federal financial grants were in close proximity to those of the ETHs. My visits to CERN, DESY, in Grenoble, Los Alamos, Brookhaven, and Oak Ridge had made it clear to me that good user laboratories are subject to such suspicions. A management that has made excellence of research conducted at its institution a hallmark, has the right to act elitist.

Pretty soon it was clear to me that SIN had developed into a place of research that did not have to fear comparison with other internationally well-known institutes.

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At the end of 1987 the Federal Council decided to combine both research institutes EIR and SIN into PSI. Now the search was on for a manager. As president of the ETH Board I was being swamped with advice that was all identical: Neither the EIR director nor the SIN director could be considered for the management role; no, only an outsider would be able to fuse “both cultures” into a new whole. I listened to the arguments, but I did not believe them. After all, Blaser knew both “cultures” – to the extent that they existed – by being part of them for years. He had supported the merger and had meticulously prepared for it. He knew how to combine existing strengths and increase their effect. He knew how to motivate staff to peak performance. The Federal Council elected Blaser as director of PSI.

This was a stroke of luck for Swiss science. Blaser handled his responsibilities with bravado and thereby created the foundation that would blend the strengths of SIN and EIR into the charisma of PSI.

Dear Jean-Pierre: My heartfelt thanks!

Heinrich Ursprung

1 The Back Story

1.1 The Introduction of Nuclear Physics at the ETH in Zurich

The 1930s were marked by a turbulent development of the physics of the atomic nucleus. The discovery of the neutron (see glossary of technical terms in the addendum) by James Chadwick in 1932, and the first-time manufacture of radioactive isotopes by Frédéric und Irène Joliot-Curie in 1933 led to a model of the atomic nucleus which was made up of neutrons and protons, and which could be used as a basis for systematic research. Paul Scherrer, who led the Physics Institute of ETH at that time, was fascinated by the new research direction. He recognized its future possibilities early on and decided to introduce it at his institute. This decision was the beginning of an outstanding advancement of nuclear physics in Europe at ETH.

The experiments in nuclear physics all followed the same pattern, that certain materials are being bombarded with fast particles – as for instance, protons or deuterons (heavy water atoms). The mostly positively charged projectiles needed to be accelerated to a sufficiently high energy so that, in spite of their electrostatic repulsion with the also positively charged nuclei, they would collide and create a reaction. The examination of the reactions and their products made it possible to gain new knowledge of nuclear physics.

The research instruments for nuclear physics were, therefore, particle accelerators. Basically they were high-voltage generators. They created a strong electrical field which accelerated charged particles. The unit of measure for the generated particle energy was the electron volt (see glossary).

Over the years ETH built several such facilities. The experiences showed quickly that with the increasing energy of the projectiles more complex nuclear reactions could be achieved, which in turn yielded more information to be analyzed. In the beginning, the accelerators did not yet create high particle energies. Since 1936 the ETH used a so-called cathode ray tube which generated up to 140 kilovolts. In 1938, at the suggestion of Paul Scherrer, who provided the necessary means, Hermann Wäffler built a ribbon generator, according to van de Graaff, on two floors of the Gloriastrasse physics building which he was able to put into service in 1940. This created an acceleration voltage of 800 kilovolts. Wäffler and his colleagues used this device for ten years, especially for measuring the nuclear photo effect.

The Swiss National Exhibition of 1939 was the occasion for the construction of a facility by the Physics Institute of ETH, in cooperation with the Zurich company Micafil, that would create high voltage by using direct-current, the so-called tensator (see fig. 1). It was based on the principle developed by Cockroft and Walton and used a switching mechanism for the multiplication of voltage which had been developed by Swiss physicist Heinrich Greinacher. It was being shown at the National Exhibition and then housed in one of the underground chambers of the physics building which had been used for previous research. The man in charge of this equipment was Werner Zünti. The tensator reached a voltage of about 700 kilovolts and would be in use until the 1960s, especially as a neutron generator.

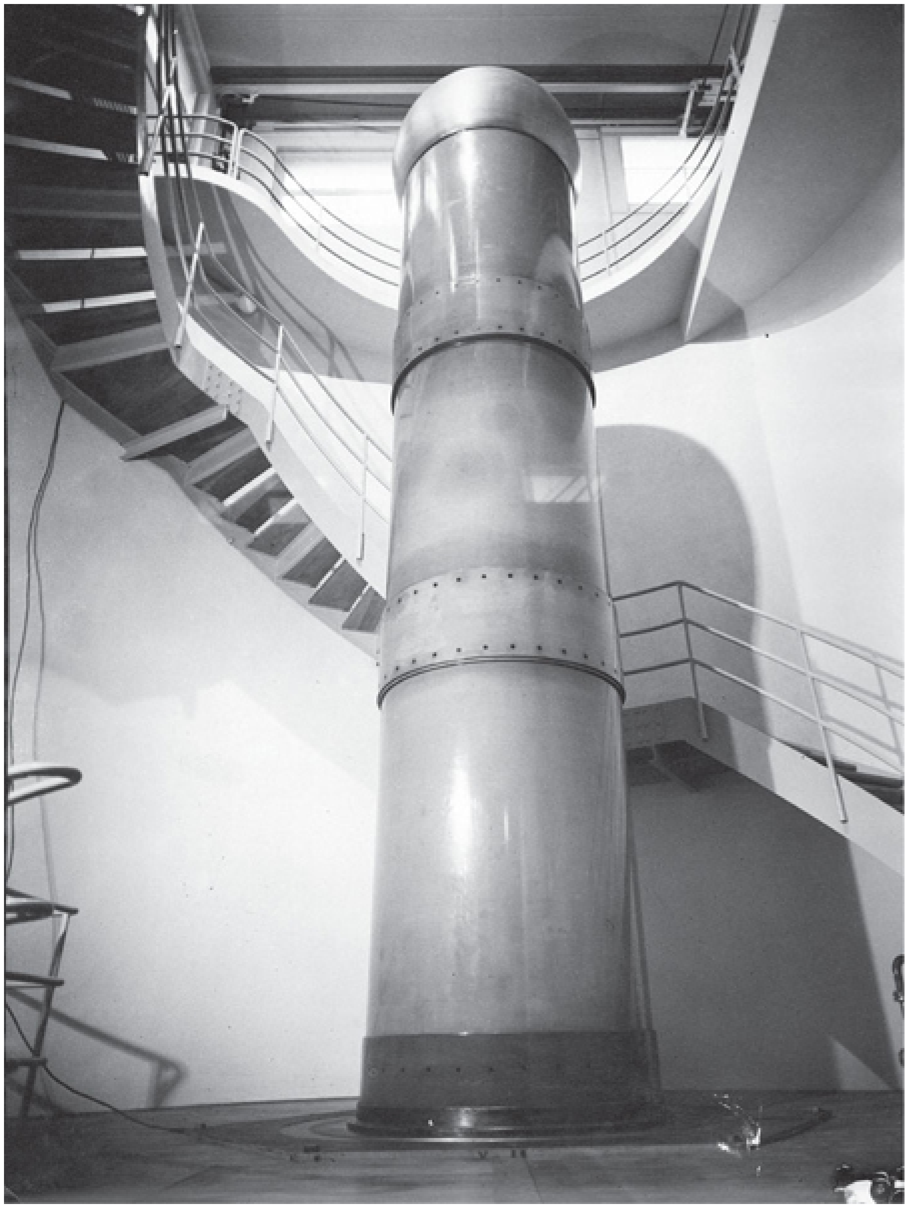

Fig. 1: Micafil Tensator at ETH

This afore-mentioned equipment served to accelerate particles under constant direct-current. If the particles started at zero, they were being directly accelerated by high voltage and left the acceleration path at the desired energy. With the available technical possibilities for creating high voltage, the physicists of the 1930s reached a temporary upper limit of 3 megavolts.

In the United States, Ernest O. Lawrence, together with his colleague M. Stanley Livingston, took a new path for the creation of higher energies. He built the first cyclotron (schematic view see below) at the University of California in Berkeley in the early 1930s. With the continuing development of the first unit, he was able to reach energies of 6.3 megavolts for deuterons. This opened new research possibilities worldwide.

With this equipment, Lawrence fabricated many heretofore unknown radioactive isotopes of known elements and sometimes even of completely new elements. In 1941, with an even higher-performance cyclotron, he was able to create mesons, known as part of cosmic rays, for the first time. Later he worked on applications of the cyclotron in medicine and biology.

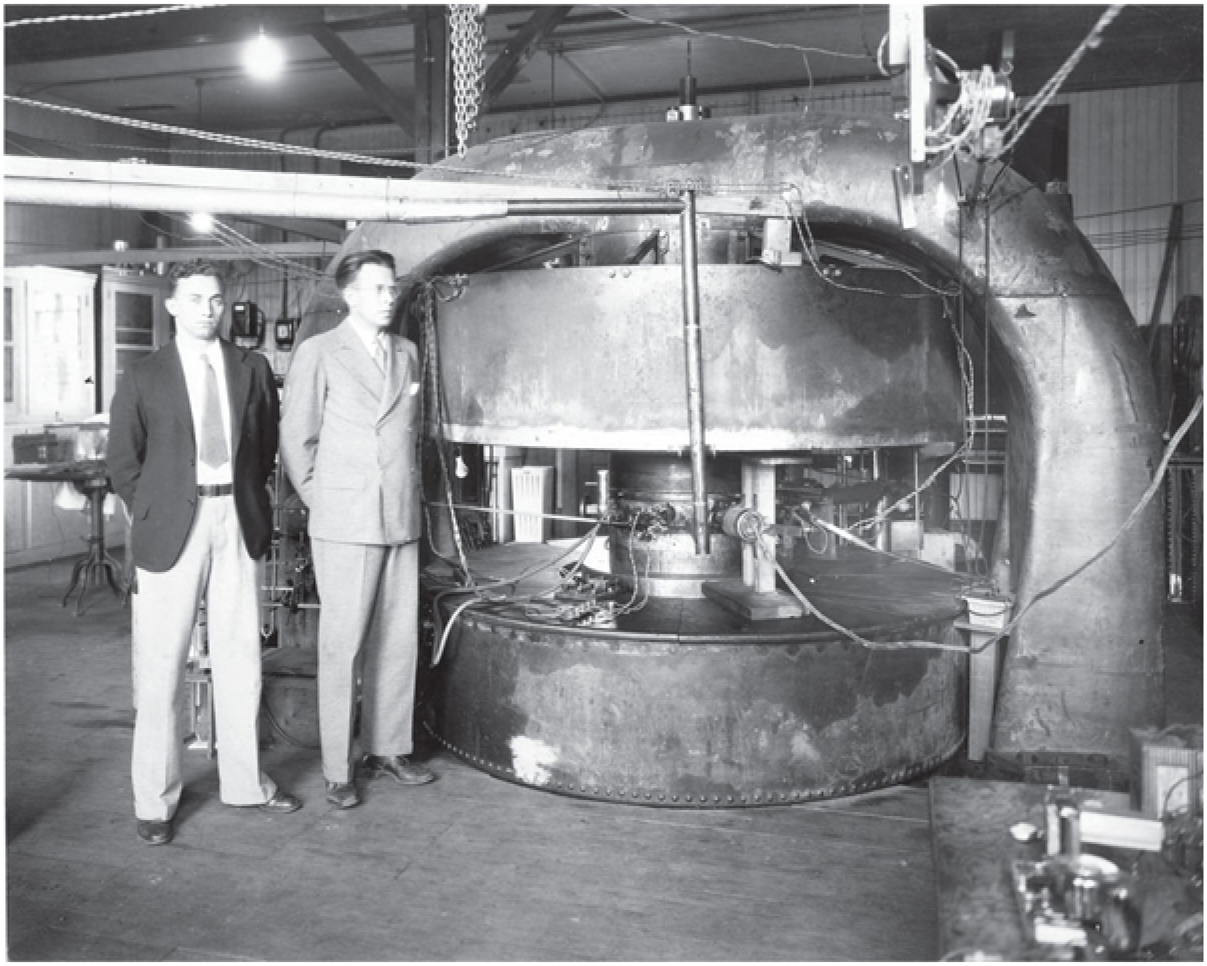

Fig. 2: M. Stanley Livingston and Ernest O. Lawrence in front of the 27-inch cyclotron in the old radiation laboratory of the University of California, Berkeley, 1934.

Lawrence got his cyclotron idea after reading the work of Rolf Wideröe about a linear accelerator in 1928. He realized that in a homogeneous magnetic field the rotational frequency of the particles is independent of their energy (isochronic). Therefore, with a constant high-voltage frequency, particles which fly through the acceleration path simultaneously can continuously be accelerated regardless of their radial position. This results in a continuous beam and a much higher intensity than with a pulsed beam, as in the subsequently developed synchrotron, for instance.

This new acceleration principle found great interest worldwide. In the late 1930s, several European institutes began building cyclotrons. Paul Scherrer, who followed these developments with keen interest, also wanted to have such an instrument for the ETH.

The main components of a cyclotron, i.e., a large electro-magnet and a powerful high-frequency generator, were expensive. Its construction required professional knowledge which precluded building it in-house. In addition, such equipment could not be accommodated in existing institute facilities because of radiation protection; it required a separate building.

As Hermann Wäffler writes in his story about nuclear physics at the ETH, the conditions for starting such a large project were favorable in the early 1940s. In the meantime, experience had been gathered with the building of accelerators, which increased the chances of finding a solution to any project-related technical problems. The ETH had also eased the conditions of employment at the Institute of Physics, and since the outbreak of the war had made a career in a foreign country impossible for an indeterminate length of time, young physicists were willing to engage for some time to come in building a cyclotron at ETH.

The Cyclotron

The classic cyclotron consists of a large electro-magnet, with a flat round vacuum chamber located between its poles. Inside that chamber are two hollow, semi circle-shaped metal chambers which, because of their D-shape, are called “dee”. The acceleration gap is located between the chambers. Affixed to the outer edge of the chamber there is a diversion condenser (septum) which is used to extract the particle stream in the direction of a specific goal.

The ions – protons for instance – are injected from their source into one of the chambers under low energy. The magnetic field guides them into a circular path. Since the ions are accelerated each time they pass through the acceleration gap, the radius of their path within the magnetic field increases. This results in a spiral-shaped path from the center to the outer edge. The electric field in the acceleration gap is created by a high-frequency alternating voltage the size of about 100,000 volts. The frequency of the high-voltage must be in sync with, or a multiple of, the rotational frequency of the ions so that they match the appropriate phase as they pass through the gap and are accelerated (rather than braked).

Therefore, in a classic cyclotron, two acceleration paths are operative per rotation. Because the acceleration paths are used over and over again, circular accelerators (cyclotrons, synchrotrons) are more efficient than linear accelerators and also much more compact.

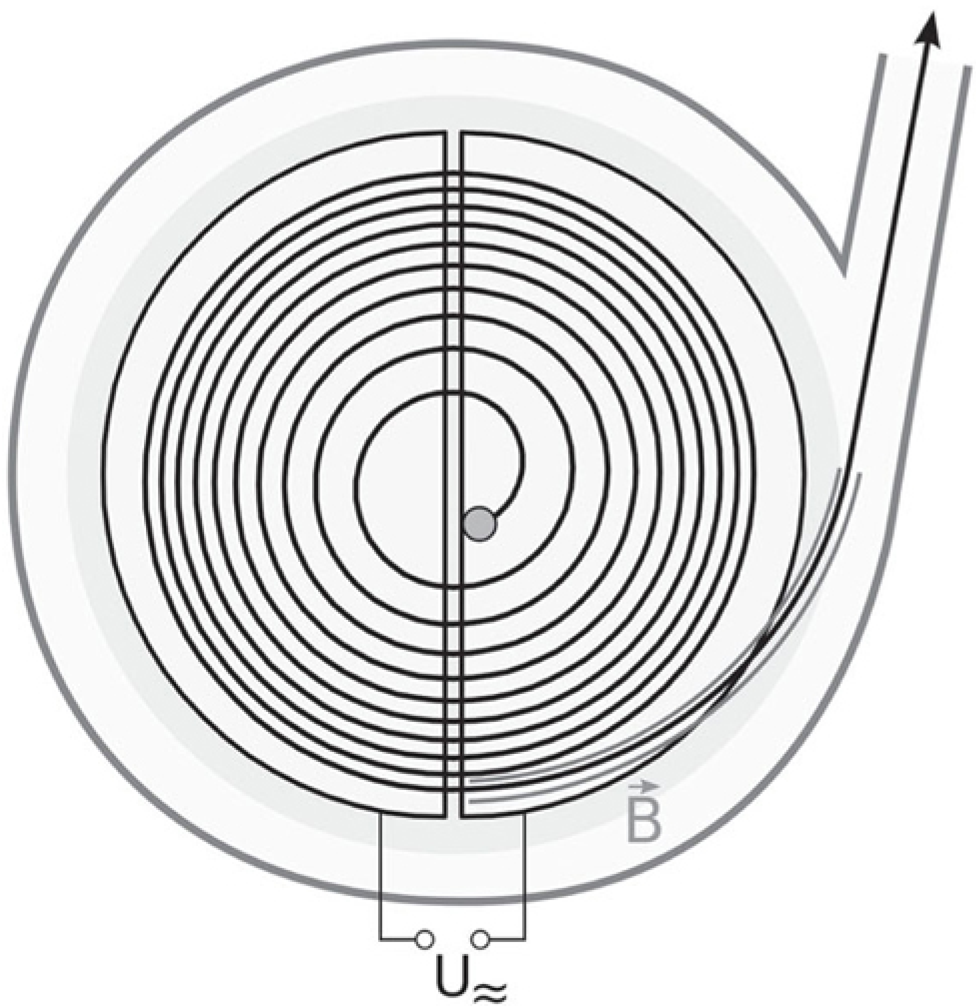

Fig.3: Schematic of a cyclotron (view of the median plane) with decreasing spaces between the particle paths towards the rim, and the extraction of the beam with a bent parallel-plate condenser.

The problem was how to finance the project. Scherrer decided to use a series of lectures in order to win prominent business people as donors. Thanks to Scherrer's highly developed art of making principles of physics easily understandable, his success was overwhelming. The institute received prominent donations for the fund of the cyclotron project. Walter Boveri, delegate of the Brown Boveri & Cie (BBC) board of directors, a friend and benefactor of Scherrer's, energetically supported the project. The company took on the building of the high-frequency generator and also made available qualified personnel for constructing the facility at the institute.

The Maschinenfabrik Oerlikon (MFO) handled the construction and building of the 40-ton electro-magnet. Most of the remaining components could be designed and manufactured at the Institute of Physics and resulted in some new ground being broken. In charge were postgraduates Peter Preiswerk, Pierre Marnier and Jean-Pierre Blaser. The ETH financed the construction of the new building for the cyclotron. It consisted of a square room of 240 square meters, and was 3 meters high on the inside. Because of the necessity for radiation protection, the building was constructed 3 meters deep into the ground and was connected to the institute building by an underground corridor.

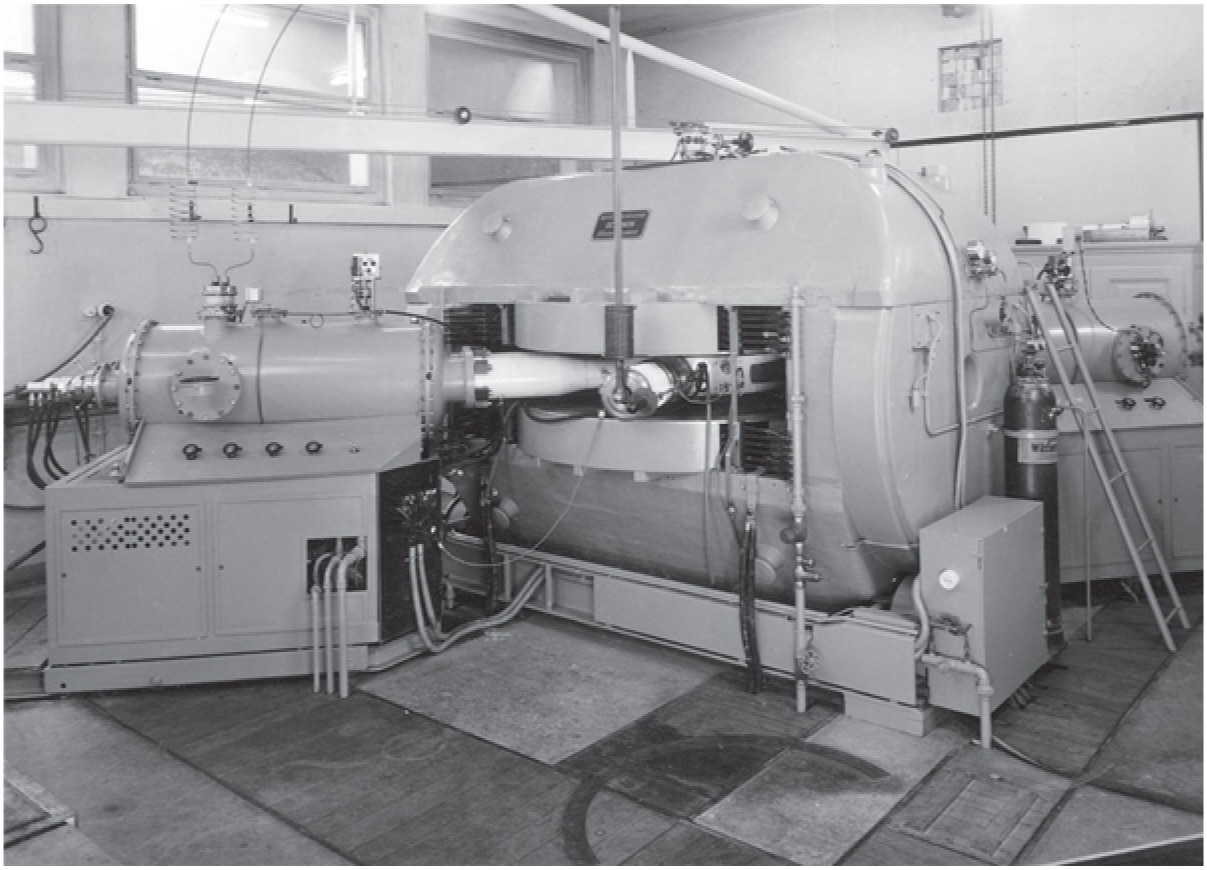

Fig. 4: The ETH Cyclotron

The ETH cyclotron (fig. 4) made nuclear reactions with protons and deuterons possible and was projected for energy generation of 15 megavolts. On commissioning the unit, an unexpected effect was observed that was not understood. The rotational direction of the particles should have been symmetric, thereby allowing both directions. However, it was asymmetric and did not match the construction of the unit, so that the beam could not be extracted. At first, only samples could be irradiated inside the chamber. Since this asymmetry could not be understood or corrected – this was the time before computers! – the physicists had to rebuild the unit by turning the cyclotron chamber around. That allowed the particle beam to be extracted.

From 1944 until 1964, the ETH cyclotron was used exclusively for the acceleration of protons. As it turned out, the phenomena generated by the proton reactions gave rise to so many different, interesting questions that they kept the cyclotron work groups fully occupied.

When the exploitability of the ETH cyclotron slowly came to an end, the time had come to think about more powerful equipment for nuclear physics. For that purpose Scherrer formed a cyclotron planning team (see paragraph 2.1).

1.2 The Step towards High-Energy Physics: The Founding of CERN in Geneva

The research results of the 1930s and 1940s in the area of nuclear physics encouraged physicists to increase the energy of accelerated particles by an order of magnitude. This trend towards high-energy physics, just like other similar developments, had their start in the USA. It had the result that the particle accelerators got constantly larger and technically more complex. Not only their construction, but also their operation became ever more costly and demanded ever more professionalism. This exceeded the technological capabilities of single university institutes. Therefore, several countries founded national research institutes. Even an international effort became logical for particle physics with highest energy demands and huge, expensive equipment.

When World War II ended, war-torn Europe no longer led the world in science. Therefore, a number of well-known European scientists in the area of atomic and nuclear physics – among them Louis de Broglie, Pierre Auger and Lew Kowarski in France, Edoardo Amaldi in Italy and Niels Bohr in Denmark – took the initiative to found a European Organization for nuclear physics research. A European research laboratory would promote the collaboration of researchers in various countries on the one hand, and on the other hand, the costs of the ever more expensive equipment would be borne jointly.

A UNESCO Conference held in Paris in 1951 became the framework for eleven European countries to sign an agreement for the founding of a “Conseil Européen pour la Recherche Nucléaire” (CERN). The council began its planning work. Already at its third session in 1952 (fig. 5) – which, by the way, was presided by Paul Scherrer – the council determined that Geneva would be the location of the future laboratory. In 1953 the Canton of Geneva agreed to the project through a referendum, and the CERN agreement was concluded the same year. After ratification of the agreement by the now twelve participating European countries, Switzerland among them, the European Organization for Nuclear Research was founded. It retained the name CERN.

Swiss groups participated in CERN from the outset, since Switzerland did not want to miss the connection to high-energy physics. In the beginning, Switzerland contributed about 3 million francs annually to this European research community.