The Swiss Institute for Nuclear Research SIN

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For all who made SIN's success possible

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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.

*

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.

*

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.

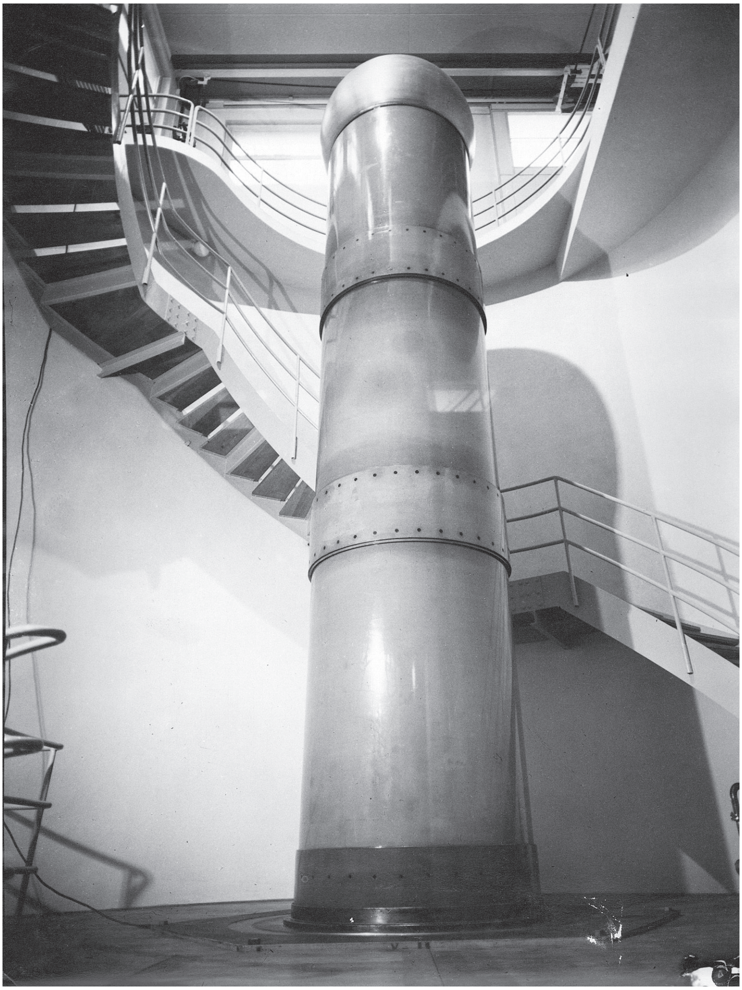

Fig. 1: Micafil Tensator at ETH

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.

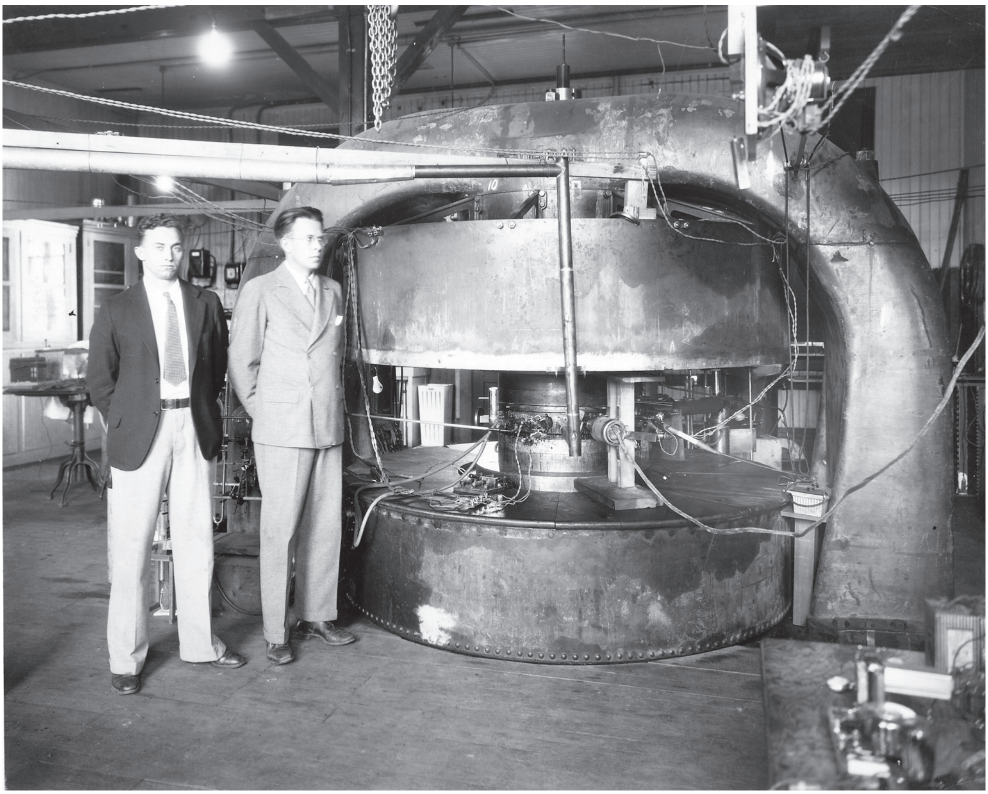

Fig. 2: M. Stanley Livingston and Ernest O. Lawrence in front of the 27-inch cyclotron in the old radiation laboratory of the University of California, Berkeley, 1934.

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.

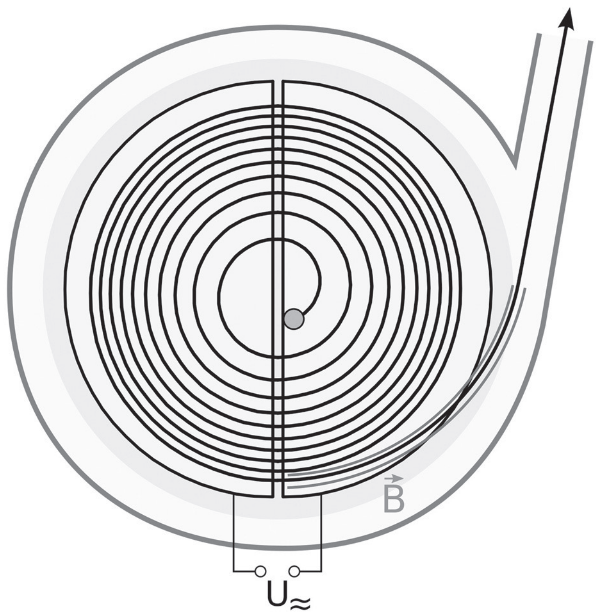

Fig.3: Schematic of a cyclotron (view of the median plane) with decreasing spaces between the particle paths towards the rim, and the extraction of the beam with a bent parallel-plate condenser.

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.

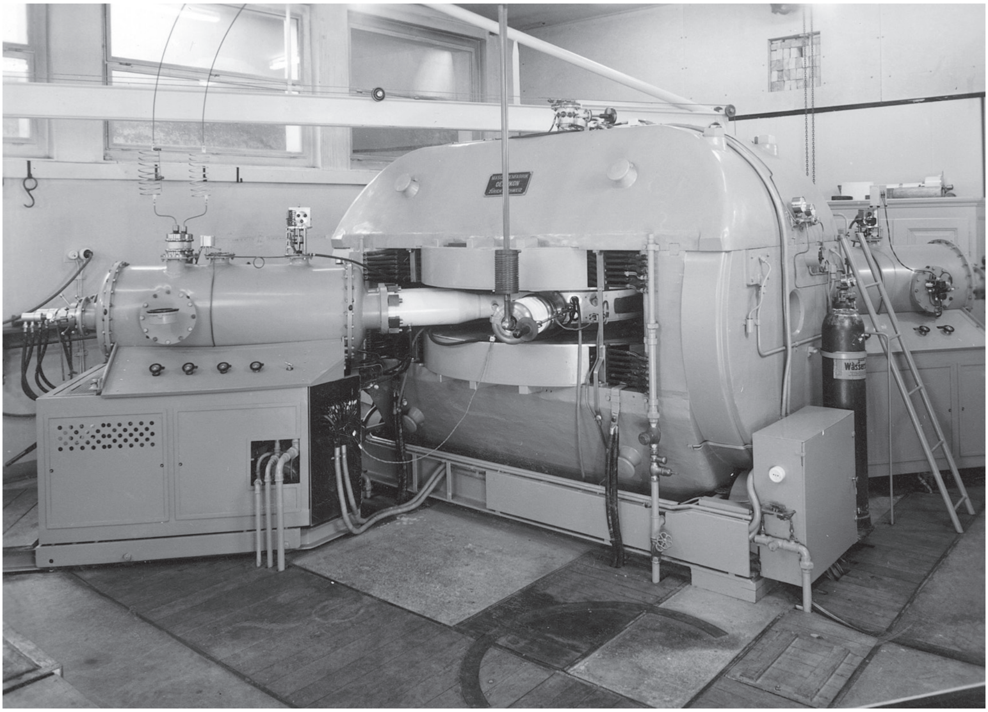

Fig. 4: The ETH Cyclotron

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.

Fig. 5: Third session of the provisional CERN Council on October 4, 1952 in Amsterdam. In addition to deciding on Geneva as its location, the Council decided to build a 25-30 GeV proton synchrotron. Presiding Paul Scherrer can be seen in the back at left and to his right at the same table, Pierre Auger, Niels Bohr, Lew Kowarski and Peter Preiswerk.

In 1957, CERN began accelerating particles with the 600 MeV synchrocyclotron. This allowed experiments not only in nuclear but also in particle physics. After 1964 this equipment was used primarily for nuclear physics since the new proton synchrotron with 28 GeV had been available for particle physics since 1959. Both machines had a long usable life. Later on, between 1967 and 1990, the synchrocyclotron supplied protons for the ISOLDE facility. It made possible the production of many different instable radioactive ions for experiments which encompassed everything from pure nuclear physics up to solid-state physics and medical applications. For a short time, the proton synchrotron was the accelerator with the highest particle energy world-wide. After CERN had built new accelerators in the 1970s, it was used primarily as an injector for new machines.

How did Switzerland end up with CERN?

Jean-Pierre Blaser tells the following anecdote: Pierre Auger had sent a circular, suggesting the founding of CERN, to the directors of all European institutes of physics, Paul Scherrer among them. Scherrer was not in favor of such a project and tossed the circular into the wastepaper basket. Peter Preiswerk, titular professor at the ETH, had participated in a discussion about a European laboratory for high-energy physics at a meeting of the Committee for European Scientific Collaboration back in 1950. He recognized the importance of such an initiative. He rescued the circular from the wastepaper basket and persuaded Scherrer to respond positively. Scherrer finally understood that only a joint European effort had a chance of catching up with the advantage the USA had gained in nuclear physics. He fully supported the realization of CERN and the selection of Geneva as its location. Preiswerk would later also contribute significantly to the development of CERN. In 1954 he took on the leadership of the CERN building department and in that function was responsible for the design and construction of the buildings and installations in Meyrin. Finally, from 1961 until 1971, he became the manager of CERN's Department of Nuclear Research.

2 The Meson Factory: From Vision to Decision

2.1 The Cyclotron Planning Team

When the usable life of the ETH cyclotron was slowly coming to an end (see paragraph 1.1), Paul Scherrer, together with the Institutes of Physics of the Universities of Basel and Zurich, assembled the so-called Cyclotron Planning Team in the second half of the 1950s. The team was planning the building of a new, larger accelerator with a budget of 10 million francs. Although the planned machine was intended for nuclear physics, and not for high-energy physics, its costs to build and operate represented a new order of magnitude, as compared with the existing ETH cyclotron. That was also the reason why ETH tackled the project in cooperation with the Universities of Basel and Zurich.

The team was led by Peter Stähelin. As a former student of Scherrer's – he would later function as research director of the Deutsche Elektronen-Synchrotron (DESY) from 1960 until 1967 – he had brought with him the concept of a cyclotron for heavy ions on his return from the USA. The planned concept was equivalent to the 88-inch cyclotron located at the University of California in Berkeley.

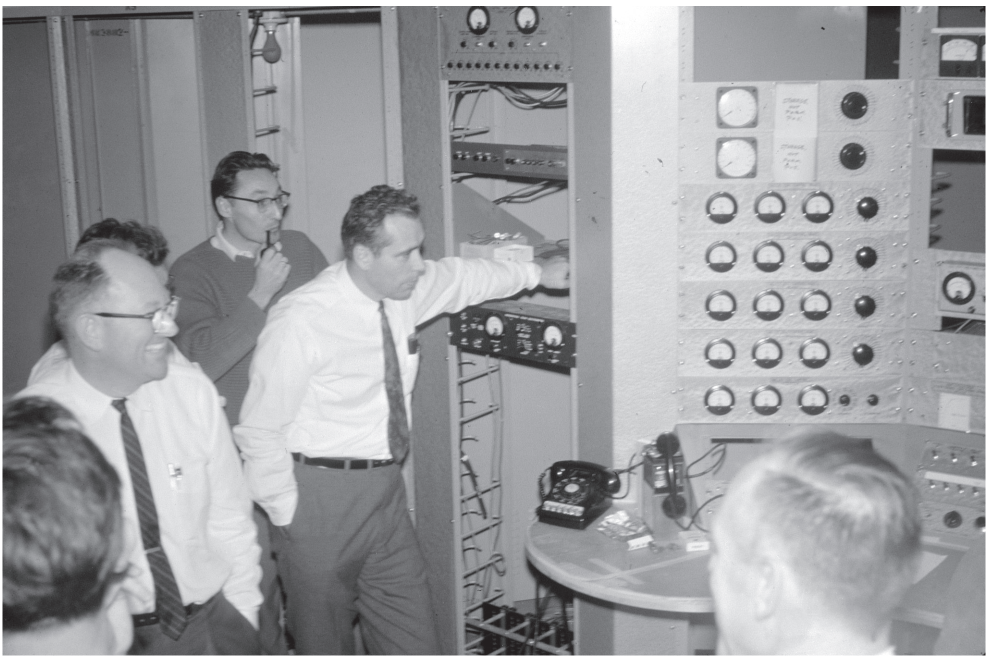

Fig. 6: From left – Bob Smith, Hans Willax and Elmer Kelly during the testing of the 88-inch cyclotron on December 12, 1961.

A few members of the team, i.e., Hans Willax, Hans Baumann and Paul Lanz, were sent there for training by Stähelin. A photo from the web page of the Lawrence Berkeley Lab (fig. 6) shows Hans Willax with the American colleagues during the testing of the cyclotron in December 1961.

In the early 1960s, the continuation of dynamic development of physics and its international importance was highly desirable for the ETH Board as the supervising agency of ETH, and especially for its then-president, Hans Pallmann. Also, ETH felt destined to seize initiatives of international importance.

This fit nicely into the political environment of the time which considered the large scientific and technical developments during and after the war as relevant to society. Especially physics was considered central to science. Nuclear physics and solid-state physics advanced to major status. They had created important discoveries, such as nuclear energy, semiconductor electronics, laser and maser, radar as well as imaging applications in medicine.

The ETH Board devoted a number of sessions during 1958 and 1959 to the development of physics at ETH. Subjects were, independent of the impending resignation of Paul Scherrer, the establishment of two new professorships, the work on the planned cyclotron as well as the succession of the late theoretician Wolfgang Pauli who had died in 1958. In its session of January 1959 it was mentioned that the ETH Professors Scherrer, Marmier, Busch and Jost, as well as Professors Staub and Heitler of the University of Zurich and Professor Paul of the University of Bonn, recommended a quick election of Jean-Pierre Blaser, director of the Neuenburg Observatory and docent at the local university, as professor at ETH. His candidacy had been considered previously by the ETH Board, but was then postponed "so as not to rob the cantons' teaching and research institutes of their best people without necessity." But now the Board considered Blaser's qualifications so important to the task that their previous consideration was set aside. The minutes of the session stated: "He is one of few Swiss physicists who knows high-energy research from his own work and has published on the subject of meson physics….He is versatile, experimental and a very talented educator." The ETH Board decided to apply to the Federal Council for the election of Blaser with a start date of October 1, 1959.

Upon the assumption of his office, Jean-Pierre Blaser took over the cyclotron planning team from Scherrer. In consideration of Scherrer's retirement in 1960, he began to newly evaluate the goals of current projects at the Physics Institute of ETH. Influenced by world-wide developments, Blaser's goal was a machine that would make participation in high-energy physics possible, rather than the cyclotron supported by Stähelin.

Such participation was highly topical. In June 1959 there had been a conversation between the president of the ETH Board, Pallman and Res Jost, professor of theoretical physics at ETH, on the subject of high-energy physics. Jost considered high-energy physics a fertile field of activity, with the possibility of gaining deeper insights into physics. In consideration of soon being able to use CERN's proton synchrotron, whose experiments were already in the planning stages, he recommended to form a high-energy physics group without delay. The discussion included the possibility of a national machine of typically 600 MeV. According to general opinion, only countries with larger nuclear physics facilities would be able to conduct efficient research at CERN.

Jean-Pierre Blaser

Jean-Pierre Blaser grew up in Zurich after his father, director of the commercial college in La Chaux-de-Fonds, was called to serve at the high school in Zurich. Nonetheless, Blaser continued to keep up with his connections at Neuchâtel. He concluded his studies at the state college in Zurich and began his studies of chemistry and mathematics at the University of Zurich. At the recommendation of Professor Louis Kollros, who taught geometry at ETH and who was, like Blaser, from La Chaux-de-Fonds, Blaser switched over to ETH in order to study physics. However, he could not find an appropriate diploma thesis with Paul Scherrer and decided to write his thesis under Professor Georg Busch on infrared spectroscopy in 1948. Blaser was interested in astronomy but could find no common ground with that professor and, therefore, became an assistant to Paul Scherrer, together with Pierre Marmier and Peter Preiswerk. With these colleagues he contributed significantly to the building of the ETH cyclotron. He concluded his studies in 1952 with a dissertation on proton-neutron reactions. In between, he spent one year at the University Sanatorium in Leysin because he had become infected with tuberculosis during his military service.

From 1952 until 1955 he spent time at the Carnegie Institute of Technology in Pittsburgh, where he did research in particle physics on the 440 MeV synchrocyclotron.

In 1955 he was named director of the Observatory of Neuchâtel, and in 1956 he became professor of astrophysics at the University of Neuchâtel. His research fields included astronomy as well as the new standard time based on the atomic clock.

In 1959 the Federal Council named him Professor of Physics at the ETH Zurich. From 1962 until 1970 Blaser managed the ETH laboratory for high-energy physics with experiments at CERN.

In 1968 he founded SIN and was its first and only director until 1987. Beginning in 1986 he managed the ETH Board's project of the merger of EIR and SIN and in 1988 became the first director of PSI, a position he held until his retirement in 1990.

His quick intellectual grasp and his willingness to examine statements critically are considered to be the most remarkable traits of Jean-Pierre Blaser. He would immediately ponder assertions of conversation partners if they did not make sense to him and was, thereby, able to assess them realistically. If he found no basis for such assertions, he would respond to them accordingly.

2.2 *The Idea of a Meson Factory*

Considering his move towards high-energy physics, Jean-Pierre Blaser also had visions of building a national center at which all universities could conduct their teaching research. It was clear that the means for such a project would have to come mostly from the Confederation. Therefore, Blaser suggested that such a national research laboratory – the future "Swiss Institute for Nuclear Research (SIN)" – would be built and operated by ETH, but would be made available to all universities. This, by the way, was analogous to the organizational structure of the large nuclear research institute in Los Alamos, New Mexico, which was being run by the University of California.

The next step was to decide on an appropriate acceleration principle. In the 1950s, several accelerators with energies of approximate 500 MeV had been built worldwide. They made it possible to artificially create the π and μ-mesons, which had been discovered in cosmic radiation, in large numbers with the help of the new synchrocyclotron principle in which packets of protons are being accelerated "in sync" under consideration of their increasing relative mass through speed. Important discoveries in physics could be made with such machines at that time, for instance, at the Argonne National Laboratory near Chicago, at the Joint Institute for Nuclear Research in Dubna near Moscow and last, but not least, at CERN. This created the need for increasing the particle currents, which were limited with the synchrocyclotron, by a factor of 100, with the goal of not just studying the mesons, but to also use them as tools. This meant building so-called meson factories.

This goal was being studied intensively in the USA, in Canada as well as in Europe. In Europe, the "European Committee on Future Accelerators (ECFA)", which was close to CERN, recommended the realization of such a facility, in parallel with the development of accelerators with considerably higher energies but only low particle currents. For this purpose, extensive studies were initiated in Germany and also at ETH. Especially the French acceleration specialist Pierre M. Lapostolle of CERN was a strong supporter of such a meson factory in Switzerland. Such a facility was intended to replace the 600 MeV proton synchrocyclotron at CERN.

The primary goal was the acceleration of protons. There were several possibilities of designing the accelerator, but the most important problem was how to control the radioactivity. With the desired beams in the neighborhood of 100 microamperes and up to 1 milliampere, the most difficult problem was the complete deflection of the beam from the accelerator. Protons, which had separated from the beam, slammed into the walls and created radioactivity there. The types of losses that had heretofore been unavoidable with cyclotrons would cause hardly controllable radioactivity.

Interestingly, the development would occur in three very different directions. Because sufficient resources were available, the research center in Los Alamos (USA) chose a linear accelerator. It allows the accelerated beam to exit the forward end without problems, but at a length of almost one kilometer, it is huge and uses an enormous amount of energy.

Fig. 7: LAMPF Accelerator

A highly interesting physics principle was chosen by the TRIUMF Research Center in Vancouver (Canada): A cyclotron which accelerates negative hydrogen ions instead of protons. When those ions are being directed through a foil at the end, which strips them of their electrons, they turn into protons and exit the magnetic field of the accelerator unaided. However, one problem is that such "stripping" is likely to also occur through the magnetic field of the accelerator which leads to losses as well as radioactivity. This calls for a weak magnetic field and, therefore, extremely large and accordingly expensive magnets. In addition, a very tight vacuum is necessary.

Fig. 8: TRIUMF Accelerator

LAMPF and TRIUMF

LAMPF (Los Alamos Meson Physics Facility) is part of the Los Alamos National Laboratory in New Mexico (US), a research facility of the American Government. It is operated by the University of California for the Department of Energy (formerly the Atomic Energy Commission). Los Alamos is known for having developed the first atomic bombs under the name "Manhattan Project". In 1972 the most powerful linear accelerator at that time was being commissioned in Los Alamos. It was mostly nuclear research that was conducted with protons that had been accelerated to 800 MeV. Today, this accelerator is used for operating a spallation neutron source.

TRIUMF (Tri-University Meson Facility) was founded in 1968 by three universities in British Columbia (Canada) in order to fill research needs that were beyond the means of a single university. It houses the world's largest cyclotron with a magnet diameter of 18 meters and a weight of 4,000 tons. Protons are accelerated to 500 MeV. Originally, TRIUMF made possible research in nuclear and particle physics. Later on, molecular biology and materials science as well as nuclear medicine were added. The development of new accelerators also belongs to the core business of TRIUMF.

LAMPF and TRIUMF, together with SIN (today PSI) are the only three meson factories in the world. The facility at SIN (today PSI) is the one with the most intensive proton beam.

2.3 *The Concept of Hans Willax*

The cyclotron planning team of the ETH chose a "normal" cyclotron with which protons were to be accelerated directly, whereby the high energy made a so-called sector focusing necessary. Since the physicists were primarily interested in meson research, rather than accelerator development, they investigated the purchase of such a machine. Indeed, many companies were active in building accelerator facilities at that time. Several quotations were investigated. The most auspicious one at that time seemed to be an offer from the German AEG for a 450 MeV isochronal cyclotron, using a continuous beam, rather than a pulsed beam as in a synchrocyclotron, of 100 microamperes of current. After an in-depth examination by the ETH planning team, now led by Willax, there were doubts whether 100 microamperes could actually be reached, and also the energy was at the lower end for creating mesons.

All of these considerations led Willax to once again deal with the basic questions in 1962. He was convinced that a so-called sector-focused isochronal cyclotron represented the best basis for a compact, economical accelerator in a meson factory, as long as it would be possible to safeguard the almost complete extraction of the beam. It was clear to him that for this purpose the proton paths up to full energy needed to remain spatially separated. All this required high-frequency voltages far above those that had ever been achieved with a cyclotron. Achieving the desired energy of 500 to 600 MeV necessary for producing mesons also made new demands on the structure of the magnet in order to assure sufficiently strong focus under relative increase of mass of 160% of rest mass.

Willax came up with the whole new idea of sectioning the magnet off into eight separate, spiral-shaped sectors and to embed between them four high-frequency cavities (fig. 9). With this structure – especially with the spatial separation between magnetic field and high-frequency system – he achieved all at once the necessary focus, and the cavities supplied the necessary extremely high acceleration per revolution with high effectiveness, thus creating separate particle paths.

However, the price to be paid for this ingenious idea was the drawback that such an accelerator could not begin at energy zero. It needed a so-called injector cyclotron which would accelerate the protons to about 10% of their final speed. Therefore, the center was missing from the main accelerator, which is why it was and still is named "ring cyclotron" or "ring" for short.

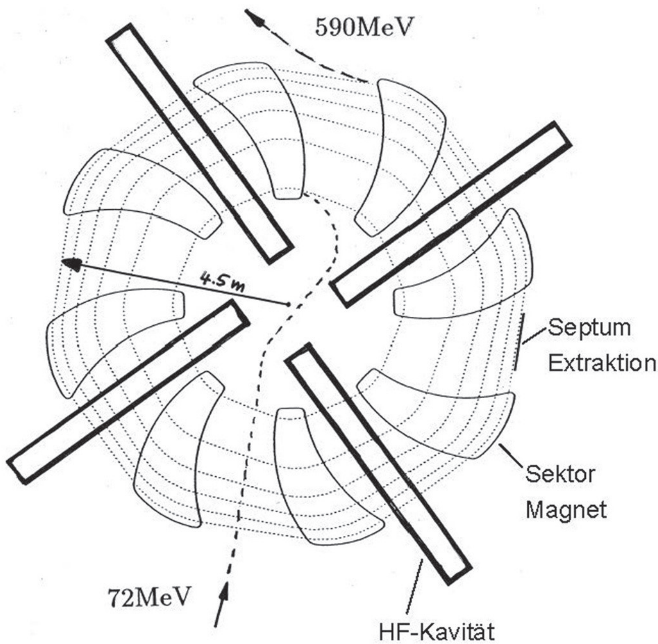

Fig. 9: The Willax Concept

Hans Willax

Hans Willax was born in 1929. He concluded his physics studies at the Technical University in Munich with a PhD in nuclear physics. In 1959 he joined the ETH cyclotron planning team. In order to work on a project of a spiral cyclotron for nuclear research, ETH sent him to the University of California, Berkeley, for two years. After his return in 1962, he became an essential contributor to the "meson factory" project, a challenging task that would become his life's work. He suggested a two-stage acceleration concept which promised high proton currents at high energy and, therefore, intensive pion rays. Willax realized his concept during the following years at the newly founded SIN. For the internationally recognized acceleration specialist it became the zenith of his career when in 1974, using his concept, protons were accelerated to 600 MeV and extracted from the accelerator for the first time.

During the development and building phase, the unusual capabilities of Hans Willax came into effect: In-depth knowledge, innovative ideas and the talent to turn a large project into

reality from an engineering standpoint. That he was able to combine these talents with great human faculties of perception for the concerns of his colleagues, would become another key to his success.
After Hans Willax had succeeded in bringing his ring cyclotron gradually up to the specified capacity, he turned his attention to a new challenge. In 1980 SIN sent him to the Nuclear Research Facility in Jülich, where he participated in the German study of spallation neutron source. While doing this work, he contracted an illness to which he would succumb in April 1981.

The two-stage Willax concept caused great enthusiasm among the members of the ETH team. When Jean-Pierre Blaser presented the new direction of the project to the president of the ETH Board, Pallmann, it caused Pallman concerns. He feared that the proprietary development would cause delays and uncertainties. And he was right. Since a meson factory had become the new goal, members of the original Basel/Zurich/ETH group had been admitted to the cyclotron planning team, if only to emphasize the national aspect. There was resistance among those members, and all of a sudden expert opinions appeared, saying that the Willax concept could not work. Since these opinions were issued from the recognized stronghold, Berkeley, Willax felt rightfully that he had been backstabbed, and great tensions arose among the planning team. To defuse the situation, the Aargau Councilor of State, Robert Reimann, was asked to act as mediator.

Reimann was a member of the National Research Council and, therefore, familiar with the universities. A great many technical and political discussions as well as committee sessions followed, leading to a vote of confidence for the acceleration concept of Willax in 1963, making it possible to continue the meson factory project on the basis of his concept. During the same year, the concept was presented to the experts during the 3rd International Cyclotron Conference at CERN where it gained much respect.

The first acceleration stage – the injector cyclotron – was to be purchased from a commercial source. In consideration of the funding proposal, with which the Federal Council would apply for the meson factory financing to the Federal Parliament, project members began negotiations with several firms. Offers were quickly received – such as from AEG and Philips – however, new ideas came up regarding the use of the injector. Based on specifications, the accelerator builders favored the machine from AEG. However, the Physics Institutes at Basel and Zurich wanted to use the injector themselves for the purpose of nuclear research, and for that purpose the machine from Philips was better suited. At first blush, it did not seem to make sense to shut down the main accelerator part-time so that nuclear experiments could be conducted with the injector. Nevertheless, the project leaders decided on the cyclotron from Philips. Incidentally, this was in accordance with a modified form of machine for nuclear physics which the cyclotron planning team had conceived originally.

Although at the time, years prior to commissioning the facility, no one dared bring up the subject, Willax and Blaser were having their own deliberations. They were convinced that the ring cyclotron would be able to create beams up to 1 milliampere, so that perhaps relatively soon the need for a new injector would arise and that such a machine would have to be built in-house and be based on the ring cyclotron principle. An accelerator made purely for the purpose of injection, such as the AEG machine, would then have to be written off. The multi-use cyclotron from Philips, on the other hand, could continue to be of use. And since nuclear physicists with their teaching-related research would be making valuable contributions to the nationally desired institutional diversification, this idea was certainly logical. It turned out to be advantageous not only from the standpoint of science policy, but also would later allow the development of a first medicine project at SIN – the treatment of melanoma of the eye – under favorable circumstances.

Accelerator Development 1962

The following episode illustrates the conditions of accelerator development at ETH at the time. In January 1962, Werner Joho approached Professor Jean-Pierre Blaser regarding a subject for his thesis. Blaser suggested that he calculate the particle beams in a cyclotron with a computer. For Joho this meant first spending three months at the computer center in Uppsala, where he learned the FORTRAN computer language, and then a deployment to CERN in Geneva where the only available super-computer in Switzerland was located. After finishing his thesis, Joho was accepted into the cyclotron planning team by Blaser and was named group leader of beam dynamics.

2.4 The ETH Funding Proposals 1965 and 1972

The next step was planning the funding. ETH Board president Pallmann decided to integrate it into the ETH funding proposal for buildings of the Federal Council for the year 1965 to be submitted to the Parliament. This building budget was decisive for the development of ETH because it included not only the meson factory in Villigen, but among other things also the new campus – the so-called ETH satellite – in the Höngg suburb of Zurich to be dedicated first to physics. This budget meant debt to the tune of 444 million francs. Of those, 218 million were planned for the Höngg campus, and for the "construction of a research facility for nuclear physics with an accelerator of high intensity for protons of 500 MeV in Villigen (AG) (High-Energy Physics)" – its official title – 92.5 million francs.

This budget had been prepared by the middle of 1963, primarily by Willax, but also by Architect Schindler of Zurich for the buildings, in cooperation with the Federal Construction Office. The physicists submitted a restrictive budget. President Pallmann was clear on how challenging this project would be. He wanted to make sure that sufficient funds would be available, especially for the construction of the innovative equipment for experiments. He, therefore, made sure to include sufficient reserves in the budget. Additionally, the expected cost increases by 1965 were included.

Building Budget Plan 1965

Total credits were divided as follows (in million francs):

Construction of the proton accelerator	*30.0*
Housing for accelerator with halls for experiments	*20.0*
Operations building	*8.2*
Administration building with lecture hall	*2.5*
Laboratory building	*2.1*
Heating facility	*1.1*
Air raid precaution	*0.7*
Electrical equipment	*5.9*
General technical equipment	*10.5*
Site improvements and landscaping	*3.8*
Garages and bus stop	*0.3*
Apparatus, machine tools and equipment	*4.0*
Furniture	*0.5*
Unforeseen expenses	*2.9*
Total	**92.5**

The meson factory was built on a "Greenfield site" (see fig. 10). The site improvements included a bridge across the Aare River leading to the already existing Federal Institute for Reactor Research (EIR). This allowed joint usage of infrastructure belonging to EIR.

The cost for the beam facilities (proton beam, targets, beam dump) to be developed and adapted to each research project, were financed by appropriately generous annual equipment credits (in the first budget of SIN of 1974, they amounted to nearly 13 million francs). The costs for shielding the beam facilities were included in the housing budget.

Not included in the above budget, but mentioned in the budget plan, were the costs of acquiring the unimproved property of 1.5 million francs, which had already been concluded, as well as the costs – mostly salaries – of the meson factory development to date. These costs were financed by the operating budget of ETH.

For reasons of transparency, the expansion of existing buildings and the construction of additional ones were already mentioned in the budget plan, but application for credit was postponed because of the need to wait for requirements to develop.

For the later operation, the budget plan included about 200 qualified team members, which would cost between 7 and 10 million francs annually.

The funding proposal gives as reasoning for the new facility essentially the arguments described under paragraph 2.2. When one considers that this text was addressed to parliamentarians, who were hardly familiar with the subject matter, it was a masterpiece of general comprehensibility. The text also describes the expected diverse scientific usability: Advancement of nucleonic and meson physics at low energies, especially considering the kind of precision measurements for which no appropriate accelerator exists; nuclear physics at high energies – an area that would break new ground; new applications in radiation medicine and biology; manufacturing of special isotopes for chemistry, biology, technology; tackling problems of solid state physics and technology. It was also mentioned that the specialists at ETH and their international advisers had already prepared a diverse list of important experiments for the utilization of the facility.

The funding proposal also explained the reasons for the location near the EIR. Alternatively, the ETH satellite in Höngg could have been chosen. In favor of Villigen was the purely "industrial" character of the facility which would have been a poor fit on a campus. Additional important considerations were the safety aspects (fencing and radioactive shielding), space requirements, accessibility to cooling water and to a high-voltage power line of the electricity company Nordostschweizerische Kraftwerke AG (NOK), as well as the proximity to EIR with its existing infrastructure. Without being mentioned, it was logical that a Villigen location would be considered more "neutral" by the universities than would have been a location owned by ETH.

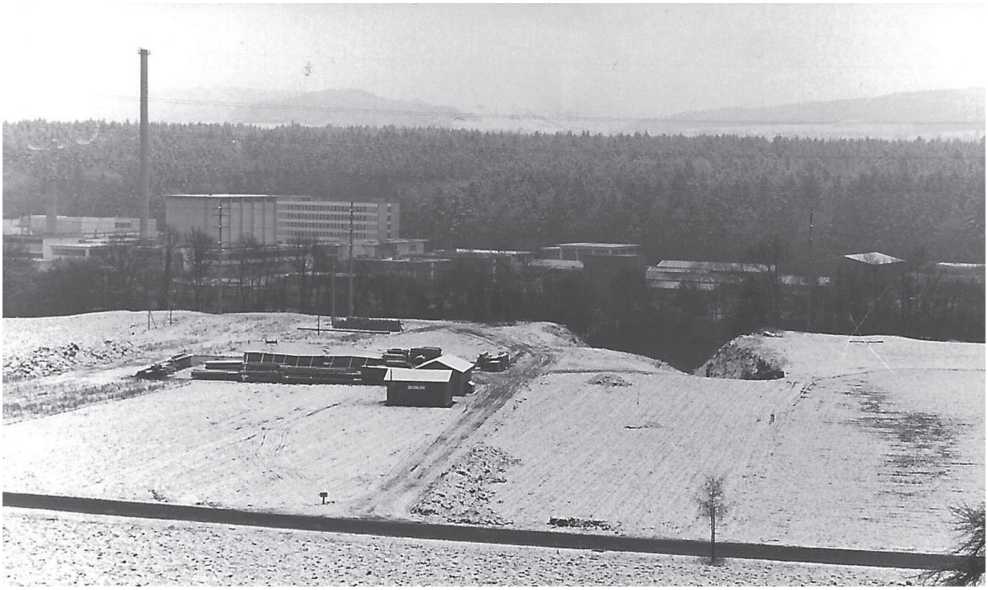

Fig. 10: Construction site on the western bank of the Aare River December 1968

All of this sounded very optimistic – and the later development would justify such optimism. But for a long time this project was not undisputed among physicists. After the funding proposal had already been prepared, another dramatic situation would develop. More than fifty renowned personalities from academia and politics signed a letter addressed to the Federal Council demanding abandonment of a meson factory for science-political reasons. It was assumed that the letter had been orchestrated by the already retired Paul Scherrer. Hans-Peter Tschudi of the Federal Council, however, was hardly impressed. He mentioned to Blaser that if so many personalities were opposed to a project, it was proof that it had an important role to play. Blaser should continue. From the standpoint of science policy the meson factory was already secured. As was mentioned in the funding proposal, realization of the project was supported in May 1965 by the Swiss Scientific Council, the Federal Council's most important independent advisory body.

The funding proposal was accepted in March 1966 by the Swiss Parliament. Unfortunately, the ETH Board President Hans Pallmann, who had pushed through the development of physics at ETH with both plans for the Höngg campus and the meson factory, would not live long enough to witness this parliamentary success. He passed away shortly before it happened. The Board's vice president, Claude Seippel, who was also supportive of the meson plant project, took over temporarily. In 1966, Minister Jakob Burckhardt of the Diplomatic Service was elected president of the ETH Board and would continue in that role until 1978.

The budgeted 92.5 million francs would soon be supplemented by a contribution from the Swiss National Science Foundation. It was obvious that the above-mentioned budget did not include an amount for the injector. A report dated summer of 1970 concerning the future tasks of SIN mentions 9 million francs which are dedicated for the construction of Injector I for the benefit of the universities. During parliamentary debates regarding the additional funding (see below), 4.7 million francs were mentioned.

In their 1972 ETH building budget proposal, the Federal Council applied to the Parliament for additional funding of 34.45 million francs, based on inflationary cost increases, for SIN which was in the process of being developed at that time. In their Winter Session 1972, the Council of States decided to eliminate the funding for SIN. This action had been led by Basel State Councilor Willi Wenk because an Injector II had been mentioned in the documentation. Funding for this injector was not part of the funding application, but SIN had announced at the same time that they intended to build a new injector. What obviously bothered Wenk was that, together with an application for additional funding for the completion of the SIN facility, it was already being considered in need of improvement. During a hearing conducted by a National Council Committee at SIN, Director Blaser declared that Injector II was not a subject for discussion. The intention was to finance it partially from SIN's operating budget (1 million francs annually) and partially through savings on additional facilities.

Federal Councilor Hans-Peter Tschudi, supported by the Federal Finance Department (which was represented by Vice Director Hans-Ulrich Ernst in SIN's building committee), was strongly in favor of granting the additional funding, as evidenced by the following citation from the Bulletin of Federal Councils:

"The Finance Department is able to judge this request for funding because management of the Finance Department is involved in the building committee for the Swiss Institute of Nuclear Research. I must emphasize – as Mr. Wenk has already mentioned: The Finance Department is of the opinion that an exemplary facility is being built here which can serve as a model for others in regard to planning and cost-efficient construction, meaning that the best report card can be given with respect to cost efficiency, good construction organization and excellent construction planning by the Building Commission under the leadership of former Brown Boveri director, Mr. Seippel, PhD."

In spite of such a strong testimonial, the Council of States denied the additional funding. However, during the spring 1973 session of a Federal Commission under the leadership of Mrs. Lilian Uchtenhagen, it was supported. Additional support came from parliamentarians from French-speaking cantons active in science policy who cited positive statements made by CERN in regard to the SIN facility. Especially Geneva's State Councilor Olivier Reverdin, who also presided over the Swiss

National Science Foundation, was in favor. This would indicate that the directors of SIN, who had been active in science-political circles, were being successful. The National Council unanimously passed the request for SIN funding and passed the matter back to the Council of States. State Councilor Wenk remained opposed, but the tables had been turned so that the Council of States passed the additional funding in March 1973.

Therefore, the early investments in the SIN facility (including site acquisition and contribution from the national fund) ran to about 137.5 million francs.