KEK News

Vol.3 No.2

A brief history of INS-Electron Synchrotron
Dawn of KEK: from Tanashi to Tsukuba
International Collaborations fostered at Tanashi

High Energy Accelerator Research Organization

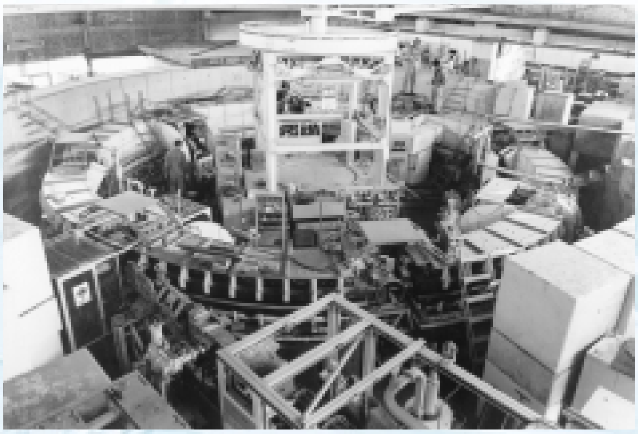
A brief history of INS-Electron Synchrotron

In 1945, the Allied Forces occupying Japan after the WWII were working to disarm Japan. The General Headquarters (GHQ) forbade all research activities on the nuclear energy irrespective of the nature of the research. In 1946, to the grief of Dr. Y. Nishina, Tokyo 60" cyclotron at Institute of Physical and Chemical Research (Riken) was destroyed. Other accelerators in Tokyo, Osaka and Kyoto were also dumped into near-by ocean. Since it happened soon after the nuclear bomb tragedies in Hiroshima and in Nagasaki, people were scared about nuclear-whatever, hence made no special effort to protest the action taken by the Allied forces on the Japanese cyclotrons.

The destruction by the military administration surprised even American scientists. In 1951, Dr. E. O. Lawrence visited occupied Japan to persuade GHQ for rebuilding cyclotrons. Following year, 1952, the peace treaty between Japan and a part of Allied Forces was made, permitting the construction of an accelerator. Though the country was still suffering from shortage of everything including food, Japanese nuclear scientists enthusiastically rushed to reconstruct cyclotrons at Osaka and Kyoto Universities and at Riken in Tokyo. Inspired by the dramatic discoveries of new particles at Bevatron of Lawrence Radiation Laboratory in Berkeley, general consensus of nuclear physicists focused on the construction of electron- or proton- synchrotron with energies sufficient to produce mesons.

Since the budget for larger accelerators was far beyond the capacity of a single University, a new type research center was conceived as the facility shared by all researchers in Japan. To assure the efficient and fair use of the facility, the Japan Science Council and the Ministry of Science and Education (Monbusho) agreed on five guiding rules to manage such facility since such research facility that is not a part of a university was a totally new concept by then. Despite of the established rules, operation of the facility required a lot of discussions to get the agreement accepted by many relevant people especially on how the facility should be shared. (20 year later, these five principles were still active and were applied to the guiding rules of KEK except that KEK is directly under Monbusho rather than associating with a particular University.)

The Institute for Nuclear Study (INS), University of Tokyo, was founded in 1955 in Tanashi City, to which nuclear physicists expected a great future. However, the high energy accelerator construction was delayed for 2 years, since the variable-energy 60" Cyclotron, convertible to 55 MeV FM mode operation, was to be built first by the initiative of the INS. The Cosmic-ray and Theoretical Physics Divisions were also established in addition to the Low Energy Physics Division of INS.



Open view of 1.3 GeV electoron synchrotron, roof shield is not yet installed.

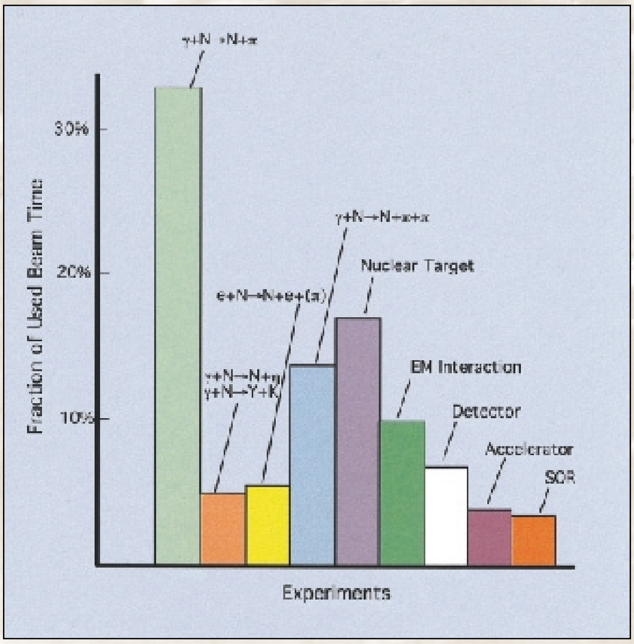
Construction of the INS 0.75 GeV electron synchrotron (ES) was finally approved in 1956 as a 4-year project to stay within the maximum available budget of 254 Million Yen. At the beginning, this machine was considered to be a machine to study accelerator technologies and not the machine for serious physics research. In these days, it was considered to be a proper approach to build a 1/10 scale machine to study for the full construction of a large accelerator. Many scientists optimistically thought that a larger machine would follow after the study period of this accelerator. We had to wait for another 15 years before the next machine, 8 GeV proton synchrotron at KEK, which delivered its first beam in 1976.

Facilities for experiments were built during the years between 1960 and 1967 with the budget of 95 Million Yen. Included were beam lines, electron extraction system, 16-ton analyzer magnet and minimal detectors with electronics. According to my memory, our group got 6 high-gain photomultipliers and a block of plastic scintillator (produced by cosmic-ray physicists) for the first experiment.

In 1961, about 60 scientists were assembled to organize a particle physicists' council named as "Japan Association of High Energy Physicists". Today the membership of the Association grew to more than 600 with the advance of particle physics.

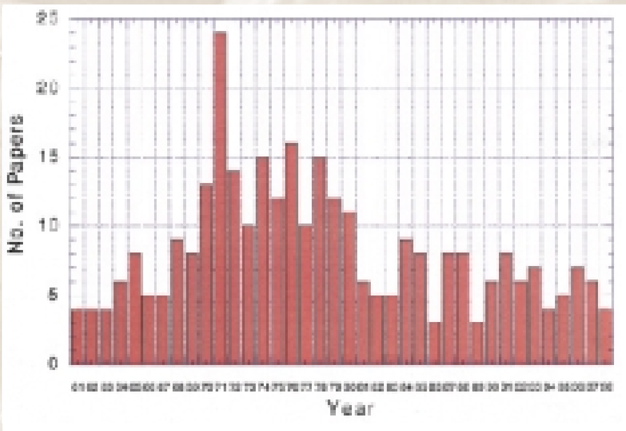
The first official call for proposals was announced in 1963. However, in the first series of experiments, average number of electrons accelerated in the ES was only 5×10^{10} per second. Hence the aim of the first series of experiments were preparatory study for the next proposals. With the early experiments, newcomers in particle physicists trained themselves for the basic technique of measurements and instrumentation. Major transitions were in electronics where vacuum tube cirsuits were replaced by transistor circuits and on-line data acquisition system started with small computers, such as PDP-5 and PDP-8. During the following 10 years, Japanese particle physicists had to work hard for producing their detectors by themselves as much for the research work.

In 1963, INS-ES received substantial budget to upgrade experimental facilities for more sensible experiments, and eventually upgraded energy from 0.75GeV to 1.3GeV. The average number of accelerated electrons increased to 8×10^{11} e/s thanks to the upgrade of the injector, beam detuning and so forth. The roof of the synchrotron was covered with concrete in 1966. Though the beam energy was not high, there still were plenty of important observables not yet measured in the energy range of the ES. In the first 20 years, main subjects of research coherently aimed at single meson photo-production experiment, particularly the polarization asymmetries in the meson photo-production which were essential to qualify quark-models of nucleon. To determine photo-coupling of a nucleon resonance without theoretical assumptions, there were 4 independent helicity amplitudes in the photon-nucleon system. In phenomenological analysis to determine the photo-coupling of nucleon resonance, we need data for cross section, polarized beam asymmetry, polarized target asymmetry, recoil nucleon polarization, and double polarization parameters G and H with both proton and neutron targets. There were also topics-hunting experiments with electron or photon beams: i.e. the quasi-free scattering of electrons from nuclei, exploring possible evidence for dibaryon resonance in photo-dissociation of deuterons, etc.



The fraction of beam time used by various experiments at ES in early 20 years. Single pion photo-production experiments show a dominant peak.

The fraction of beam time used for these subjects were summarized in upper graph for the first 20 years, where single pion photo-production experiments exhibited a remarkable dominance over other reaction channels.



Number of publications from INS-ES experiments between 1961 and 1998. The first series of experiment at KEK-PS started in 1977.

The number of annual publications from the ES experiments are plotted in lower graph. The histogram shows the most productive period of INS-ES from 1968 to 1980. By the end of 1960s, group to prepare for the next accelerator started in INS. This group initiated the construction of a proton synchrotron (KEK-PS) in Tsukuba which is the early stage of present KEK. (See article by Kihara in this issue on the transition from the INS to KEK)

After the completion of KEK-PS where the first series of experiment began in 1977, INS-ES was mainly used for the complementally researches to the hadron beam experiments. The high duty tagged beam line was installed to explore nuclear science at intermediate energies, i.e. photo-dissociation of light nuclei, multi-meson photo-production from light nuclei, etc.

I think that the research works at the INS-ES did a great contribution in establishing quark-model of nucleons. In addition to physics, plenty of photo-production measurements were still highly appreciated in detector design studies, especially by providing the analyzing power of polarization.

The INS-ES played the role of mother for Japanese high energy physicists for the difficult 15 years when there was only one available accelerator in Japan, providing the opportunity to learn and experience. Over 100 scientists who did experiments in the ES are still quite active in the frontier of research. Experiments in the ES also resulted 102 Ph.D. thesis.

In concluding my brief review, I dare say, "without the years of INS-ES, the success of present KEK would not be there". The small machine left a big footstep on the particle physics in Japan.

The author of this article, Dr. ***Ryoichi Kajikawa***, was one of the prominent physicists who propelled the INS experiments as a professor of Nagoya University.

Dawn of KEK: from Tanashi to Tsukuba

The year of 1964 should be remembered among us by the fact that the Japanese High Energy Physics Community made a historical step toward the realization of a new institute for high-energy physics. The Japanese Government allocated one hundred million-yen to start a research for the proposed high-energy accelerator project: a 40-GeV proton synchrotron. A preparatory group, directed first by Prof. Sin-itiro Tomonaga and later by Prof. Hiroo Kumagai followed by Prof. Shigeki Suwa, was formed in the Institute for Nuclear Study (INS).

The project of constructing such a huge accelerator was a truly big technical challenge for Japanese high-energy physicists of 1960s. In those days there were few physicists in Japan who had experienced high-energy proton accelerators of that size. Prof. Suwa, who was distinguished by his leading role in the polarized proton beam project at the Zero Gradient Synchrotron of Argonne National Laboratory, came back from U.S.A. in 1966 to direct the preparation. Also, Prof. Tetsuji Nishikawa, who is famous for his invention of the alternating periodic structure concept in linear accelerators and had research experience at the Alternating Gradient Synchrotron of Brookhaven National Laboratory, became the leader of the preparatory study for accelerator systems.

The number of full-time staffs dedicated to the project was not so large. Hence, a number of university professors, research associates and even graduate students of high-energy physics were involved part-time in the research groups as visiting collaborators. They were very keen to bring the project into being quickly and the group's spirit was very high.

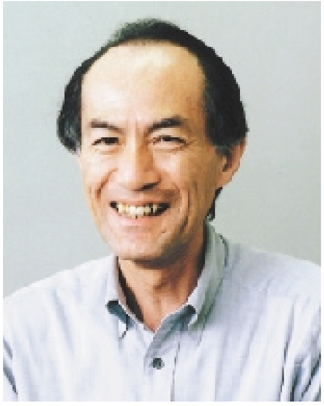
While the preparatory study proceeded well, we had to wait for years until we got the approval of the project itself by the Government. This must have been partly due to that the project size (roughly 30 billion-yen) was so large compared to ordinary scientific investments of those days, and partly due to a controversial issue about the structure of the institution to be built. In 1969 the Science Council submitted a report to Monbusho recommending the foundation of a new high-energy physics institute with the construction of an 8-GeV (not 40-GeV!) proton synchrotron. Eventually, after lengthy negotiations for six years with the Government, KEK came into being on April 1971 in Tsukuba, which is located 50 kilometers north of Tokyo. In those days, the Tsukuba Science City Project was going on with a Government's initiative to centralize national research laboratories in this newly developed area. KEK became the second national laboratory that appeared in the city. The construction of a 12-GeV proton synchrotron started at the same time. Although the unfortunate reduction of the accelerator came with it, the founding of the KEK was the dawn of high-energy physics in Japan in the real meaning. Before KEK was born, the 1.3-GeV Electron Synchrotron in Tanashi was the only GeV-class accelerator in our country. Graduate students majoring in high-energy physics of the day started their research careers through experiments they did at Tanashi. Many of them, including myself, joined the 12-

GeV Proton Synchrotron Project as staffs of KEK. The construction was actually quite exciting for young high-energy physicists.

It should be noted here that the Science Council, by considering rapid progresses in high-energy physics, recommended in the report the necessity of promoting a second-phase plan of the facility in the future. This statement must have had a big impact for the high-energy community to start the next-phase high-energy project. A design study for the future project started in parallel with the construction of the Proton Synchrotron, under the leadership of Prof. Nishikawa (Director of Accelerator Department and the second Director-General of KEK). The first proposal of the well-known TRISTAN Project was publicized in 1973: an electron-proton collider was at first investigated but an electron-positron collider of a center-of-mass energy of 60-GeV was concluded at the end.

Tanashi has been the birthplace of not only high-energy physics but also synchrotron radiation science in Japan. Synchrotron radiation research had already been carried out actively at the 1.3-GeV Electron Synchrotron since the early stage of its commissioning. Later in 1974, a dedicated light source, named SOR-RING was constructed next to the Electron Synchrotron. Both facilities were limited to ultra-violet radiation research. Hence, the synchrotron radiation community had been for a long time pursuing the realization of an advanced light source capable of providing x-rays. It was a clever idea that KEK combined a synchrotron radiation program with the next-phase high-energy physics project. By the leadership of Prof. Nishikawa and Prof. Kazutake Kohra, the grand design of the KEK's future was created. A decision was made by Monbusho that the PHOTON FACTORY (PF) with a 2.5-GeV light source and a full-energy injector should be constructed first, and that the TRISTAN share the linear accelerator section upon approval. In 1978 the PF project was launched and by March 1982 it was completed. In November of the same year, the high-energy physics community celebrated groundbreaking ceremony for TRISTAN.

By 1982, ten years after its foundation, KEK has become a really multi-field research laboratory that operates two big facilities covering wide range of research fields: high-energy physics and materials and life sciences.



The author of this article, Dr. ***Motohiro Kihara***, is the Director of the Accelerator Laboratory who was one of the driving force in starting present KEK.

International Collaborations fostered at Tanashi

Tanashi has been the birth place of many international collaborations of particle and nuclear physics. History goes back to former Institute of Nuclear Study (INS) of the University of Tokyo. The very first case that Japanese physicists joined overseas activity as a group was a cosmic-ray experiment started in 1960. In the early days of INS, when nuclear and particle physicists were busy building new accelerators, cosmic ray physicists were ready for experiments. The Bolivian Air Shower Joint Experiment, BASJE, was a collaboration of the groups from Bolivia, Japan and US performed on the Chakaltaya mountain in Andes was a collaboration of groups from Bolivia, Japan and US. Close link between an INS cosmic ray physicist and an MIT cosmic ray physicist initiated the collaboration. The experiment has been continuing for the last 40 years. Present day participants from Japan is a group from Tokyo Institute of Technology.

Japanese nuclear physicists, supported by INS, began an international collaboration at BEVALAC, Berkeley in 1979 after having made first achievement at the INS cychrotron. They gained experience from this collaboration that gave birth to new ideas for the next step of heavy-ion physics. Many of them became present leading physicists of the field. Modern Japanese facility designs can be traced back to the experience, too. Six years later, this project was terminated and a plan for heavy ion experiments at BNL was approved in the Japan-US high energy physics program. The INS group, together with other Japanese universities, carried the responsibility of R&D and construction of the detector components. With excellent particle identification capability, these experiment measured the spectra of various secondary particles from the heavy ion reactions in attempt to catch a clue on quark-gluon plasma. The group made further move to join the PHENIX experiment at RHIC in order to further seek its game. They are going to start data taking this year. Tanashi nuclear physicists made other smaller collaborations in Europe, such as at CERN, at GSI and at Niels Bohr Institute.

The INS high energy group started international activity in 1986 when they joined the ZEUS experiment at HERA together with a group from Tokyo Metropolitan University. In Japan once was a plan to include e-p collisions as the second phase option of TRISTAN at KEK. The idea was discarded when HERA was approved at DESY. Thus, it was a natural consequence to have a group participating in an international collaboration there. At DESY, there was a solid ground for the cooperation. A group of University of Tokyo had been partaking a successful collaboration at DORIS and at PETRA since 1972. The group shared responsibility in constructing several detector components and global first level trigger. In the R&D and construction stage, the expertise and the infrastructure at the INS electron synchrotron and the INS computer center proved to be very helpful. The contribution from Tanashi helped the team to be successfully in the large international collaboration.

Later, another group was formed including researchers from KEK and from Japanese universities to participate in a Kaon decay experiment at BNL. This group also enjoyed the benefit of the expertise at Tanashi in building the detector components which resulted substantial contribution to the experiment. During the last decade, the 1.3 GeV electron synchrotron in Tanashi received groups from Russia and Canada hosting international collaborations. In these collaborations, graduate students gained good experience and knowledge. These young physicists are now the major contributers in many of the big experiments.

Theorists initiated a different type of international activity in 1973. They organized a series of symposiums which became known as INS International Symposium. Its topics were later extended to cover experimental and accelerator physics. It was kept going annually as KEK-Tanashi International Symposium until last year.

The author of this article, Dr. ***Sakue Yamada***, was the last director of INS and is the present Director of IPNS of KEK.

People at the Tanashi 1.3-GeV Electron Synchrotron

On June 4th this year, the 1.3-GeV electron synchrotron at Tanashi terminated its operation after 37 years of service for the particle and nuclear physics experiments. This accelerator was the first high-energy accelerator that played a critical role in developing high-energy physics research in Japan.

In recent years, the accelerator was very stable and the running time was about 2,500 hours per year on average, thanks to the accelerator staffs led by M.Muto.

The electron and photon beams had been used primarily for the nuclear physics experiments. A tagged photon beam with a duty factor of 20% and a magnetic spectrometer "TAGX" with a 2π solid-angle were installed in 1985. The TAGX collaboration, led by K.Maruyama, consisted of more than 50 participants including those from abroad, made a series of pioneering experiments on photo-nuclear reactions.

The main subjects were;

1) study of photon absorption mechanism on nuclei through photo-disintegration of deuteron, ^{3}He and ^{4}He,
2) study of Δ and $\Delta\Delta$ in nuclei through π photoproduction,
3) K^{+} photoproduction on nuclei in the subthreshold region, and
4) study of ρ^{0} mass shift in the nuclear medium through ρ^{0} photoproduction on ^{3}He, ^{4}He and ^{12}C.

Results from these activities were summarized at the 2nd KEK-Tanashi International Symposium on "Hadron and Nuclear Physics with Electromagnetic Probes" held on Oct. 25-27, 1999.

In recent years, in addition to the above, the electron synchrotron beam had been widely used for various interdisciplinary researches. A group of I. Endo, K.Yoshida (Hiroshima U.) and N.Imanishi (Kyoto U.) studied various coherent radiation phenomena by electrons passing through the periodic structure of matter such as single crystals, which included parametric X-ray radiation, channeling radiation, coherent bremsstrahlung and resonant transition radiation. Applications of these phenomena to the intense X-ray source and the positron source were experimentally tested.

Another subject long been studied by S. Shibata (Kyoto U.) and K.Sakamoto (Kanazawa U.) was the cross-section measurements of photon-induced spallation and fragmentation processes on nuclei by the radiochemical method. After 15-year accumulation of the comprehensive data, they provided the world-best summary of these processes.

Various short-termed and / or parasitic experiments were also carried out using the electron and tagged-photon beams, including tests of various particle detectors for use in particle-, nuclear- and cosmic-ray physics experiments. Further, this electron synchrotron had long been used as an injector for the 500-MeV storage ring operated by the Institute for Solid State Physics of Univ. of Tokyo for researches using synchrotron radiation.

The Tanashi 1.3-GeV electron synchrotron played a historical role in developing the particle and nuclear physics field and the synchrotron radiation field in our country. Although these research activities were terminated at Tanashi, it is expected that they will be continued or further developed at the electron accelerator facilities around the world.

The author of this article, Dr. ***Hideki Okuno***, is the Tanashi electron synchrotron program coordinator and is a professor of IPNS of KEK.

Genzo Takehisa, the Baroque musician

On November 1, we were very fortunate to have Mr. Genzo Takehisa as a lecturer at KEK.

He is a prominent player of harpsichord, organ and piano. His talk was titled as “Where Music meets Science”. The lecture was a part of the KEK Art Festival.

He brought in harpsichords, clavichords and an organ each tuned by different tuning method, such as Just Intonation, Pythagoras, Meantone and Werkmeister. He explained the problems Pythagoras and other ancient to Baroque peroiod scientists / musicians / composers faced in chase of a perfect tuning which should results perfect harmony without beats, as the world was supposed to be the best of all possible world. By then, music was a kin to mathematics.

This could not be done because power of frequency ratio of 3/2 (fifth) can not make up a frequency ratio of power of 2 (an octave). Hence the breakdown of beautiful harmony in the Universe. He demonstrated this and all sorts of scientific approaches to reduce the beat by different tuning methods. He ended his lecture by playing beautiful harpsichord music including his own arrangement of Chaconne by J. S. Bach.

All of us in audience were made fully aware of the days that music represented the beauty of the universe and was the entrance gate to understand the nature. This in turn made us aware of the beauty in elementary particle physics theory.

Mr. Takehisa wanted to become a physicist when he was a child, but he gave up the dream when he thought that his being blind will be a big obstacle for him to do physics experiments. He then became a musician. His extremely keen sense to harmony and sound is a great gift and every sound he produces has its own colour and charm. When he plays polyphonic music, each melody become alive by itself and his left hand and right hand start singing a duet together. In front of keyboards, he soars high. Here, the audiences with vision are the handicapped beings. He becomes a champion in the mind of listeners. Like many others, I was struck by his world of music. It is hard to describe the experience but the magnitude of impact I received was as much as when I first listened to Glen Gould's Beethoven (Emperor Concerto) or Fou Ts'ong's Scarlatti Piano Sonatas. Well, listening is believing.

He is also a very good talker. Anything he talks about, from, say, cabbage to the Universe, also carries this charm. He does not play with words, yet each word shines and enchants his listeners. When a couple of us visited his studio a month after the concert, it was not an exception. He thinks that French revolution changed salon music for limited patrons into a concert-hall music for everyone, thus achieving democracy. However, this eventually resulted a dilution of music.

He wants to bring back music closer to audience than something happening on stage where audience is simply receiving music as provided. To achieve this, he plays for a smaller number of audiences, including music of his own composition and his arrangement in the program. He says that each concert is a chance for him for a new discovery, a chance to elevate himself even higher. When he plays music that are considered to be museum pieces, the music become alive and reaches audience's soul as if it were a popular music you would be singing along. In this way, he is a contemporary. He has published 9 CDs so far and they are highly regarded by many classic music lovers.

He has been active not only as a musician. He teaches in universities and has been the member of judges for international and domestic musical competitions. He is also on improving harpsichords working with harpsichord craftsmen. For example, he knows extremely well about feathers used for harpsichord since he himself works on harpsichords to get the sound he wants. He is a present-day Baroque period musician who takes music in his hand. He is not just a music seller. He is the music.

(Tokio K. OHSKA)

(CDs currently available are : The realms of Keyboard Music Vol.1, Vol.2, Vol.3, Vol.4, Vol.5 / J.S.Bach Goldberg-Variations / J.S.Bach Organ Works Vol.1 / The Great Organ Vol.1, Vol.2)

July 28-31

Workshop on Low Energy Positron and Positronium Physics. (85)

September 4

Commemorating the final closing down of the Tanashi Electron Synchrotron, over 200 people gathered in Tanashi. After the talks on historical and scientific meaning of the Electron Synchorotron, a party followed. People who had worked at the ES sometime during the 37-year history of the ES got together.

September 15

Approximately 2,700 visitors enjoyed a tour through KEK, special lectures and other physics related demonstrations during the annual KEK Open House.

September 21-24

International Workshop on Performance in Improvement of Electron-Positron Collider Particle Factories. (99)

October 25-27

The 2nd KEK-Tanashi International Symposium on Hadron and Nuclear Physics with Electromagnetic Probes were held at the Tanashi Branch. Interesting topics on the QCD physics of in-medium hadrons such as vector mesons and strange baryons in nuclei were extensively discussed. (85)

November 2

KEK celebrated the completion of two major facilities on site; B-Factory and Long-baseline Neutrino Experiment. After a few years of construction, these facilities are now taking data. 250 people attended the ceremony.

November 15-19

The 7th International Conference on Instrumentation for Colliding Beam Physics was held in Hamamatsu (organized by KEK). Updated information on various detectors were presented. (149)

November 22 - December 4

Asian Science Seminar was held in Beijing, China as a collaborated project between KEK and Chinese physicists. 12 students from Japan, 20 from China and 13 from other Asian countries participated.

(Many International Symposiums were held during the period this issue covers. Not all of them are listed here. In the brackets are number of participants.)

Photos on front cover
There are so many pictures taken during the 37-year history of the INS.

Photo on back cover
Izumo Shrine is built in honor of a god, Okuninushi-no-Kami is located 300km west of Kyoto and is one of the most important Shinto shrine. It keeps the oldest form of Shinto shrines. While the present building, Oyashiro, built in 1744 is 24 meters high, original shrine build before 8th century was said to be 48 meters high. Many ancient stories are associated with this area, including a battle with a monster that had a body of a snake with 8 heads.

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