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REPORT BY THE JAPAN HIGH ENERGY PHYSICS DELEGATION TO CHINA, MA--ETC(U)

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# FOREIGN TECHNOLOGY DIVISION

REPORT BY THE JAPAN HIGH ENERGY PHYSICS DELEGATION TO CHINA, MARCH 1979

(Selected Pages)





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## THE CIRCUMSTANCES OF SENDING THE DELEGATES AND ITS PURPOSE

The fact that China is doing her best in developing high energy physics is evidenced by the announcement of 30∿50 GeV large scale accelerators by Vice President Hoki who is head of the National Science and Technology Committee at the National Science Conference in March, 1978. The vice president cited high energy physics as one of the eight important fields in a summary of the development projects of the National Science and Technology Conference.

However, construction of accelerators requires high technology and advanced experience in all fields. China, which is still a developing nation, cannot expect a balanced development of high technology in all fields.

It is reasonable, both historically and geographically, that Japan is considered by them as a nation which has the industrial technology necessary for construction of accelerators and advanced experience.

The High Energy Physics Institute of the Education Ministry of Japan, to which the leader of the delegate, Mr. Nishikawa, belongs, already accepted the following Chinese representatives in order to provide them with technological information which is necessary for construction of accelerators.

1) Chinese High Energy Group. Head of group, Cho-bun, visited Japan on July 5, 1977.
2) Chinese investigations group of accelerator parts and guages of Chinese Science Academy, head, Ryu Gyoku sei, visited Japan on July 26, 1978.
3) Chinese study group of automatic control systems of accelerators, head, Rai yusei, visited Japan on Sept. 26, 1978.
4) Chinese Science Academy study group of automatic control systems of accelerators (No. 2), visited Japan on January 20, 1979.

Acceptance of these groups is significant, not only for the purpose of providing technological information necessary for construction of accelerators in China as mentioned before and collaborating in the construction, but also training specialists in the field of high energy physics in the future.

We cannot deny the fact that the factors which led to sending the Japanese high energy physics delegates to China at the request of China were cooperation in constructing accelerators in China and building a foundation for scientific and technical exchange between Japan and China in the future which was desired by the people in charge of this project. For the latter purpose, this delegation is of great importance.

## Technical discussions with Chinese researchers and inspection of factories.

Based on the experience of technical discussions with Chinese researchers and inspections of factories related to accelerator construction, we requested specialists in each field to report on the present status of high energy physics in China.

## 1. High energy physics in China.

Tetsuji Nishikawa
Director, High Energy Physics Institute
Department of Education

### 1) Summaries of the Research Institute

The Chinese High Energy Physics Research Institute belongs to the Chinese Academy of Science. It is located in the area where the previous Science and Technology University was, in the west part of Peking. The number of workers is about 1,000. A new location of the experimental center was selected near Jusanryo, of the Ming Dynasty, located about 50 km east of Peking. Construction of a proton synchrotron with an energy of 50 GeV is expected to start in the near future.

The director of the institute is Professor Cho Bun yu and the vice director is Professor Shu Kogen. The main staff includes the Chief of the Accelerator, Ka Ryu, the Chief of Experiment Planning, Chu Ki, and the project leader, Ri Sho. Also, in the actual construction of the accelerator, the accelerator construction group headed by the High Energy Experiment Center Technology Director, Rin Sosho (visited Japan in January), will be organized*. By the time of the completion of the accelerator, the total number of the staff will be about 2,000. About 3/4 of the present workers are scientific and technical staff. The details are

| | |
|---|---|
| accelerator | about 240 persons |
| high energy experiment | about 150 persons |
| computer | about 50 persons |
| theory | about 50 persons |
| cosmic rays | about 80 persons |
| nuclear science (including chemistry) | about 100 persons (Van deGraaf, Electron linear accelerator) |

In addition to these, there are 150 workers in the manufacturing factories and 100 administrators.

The total budget is 2∿3 gens and the target date of the accelerator construction is 1982.

2) Scheduled area (inspected on March 4)

The area planned for the construction of the Chinese accelerator is located near the branching point of the roads to the Great Wall of China from Peking and to Jusan Ryo (13 graves) of the Ming Dynasty. It is a large area covering about 6 km square. It is on

*This accelerator construction group belongs to the National Science and Technology Committee. Therefore, the Institute belongs to both the Science and Technology Committee and the Academy of Science.

a slope facing the northern mountains. It is between two faults running along the north-south direction. The soil is mostly clay-like and the base rock is 40-70 m below the ground surface. Already three borings were done and at the end of this year, construction will start.

Buildings of the branches of Peking University and Seika University are in the area and part of them are used as the factory office of the High Energy Research Institute. It was snowing when we visited the area. We viewed the entire area from the top of a hill. The location seems quite ideal. Except for the above mentioned building of the branches of the universities, there are no other buildings in the area.

3) Preliminary research at the High Energy Research Institute

In the High Energy Research Institute in Peking, many buildings are currently in progress. Most of these buildings are being done because of the original plan for building the 1 GeV proton synchrotron in this area.

Since the 50 GeV protron synchrotron is to be built in the newly scheduled area, the present research institute is expected to play the role of an annex in the future. Many of the buildings under construction at this time will be used for preparation for bubble chambers and other experiments. Also, they will be used for experiments of model electric magnets. Especially, the large factory where manufacture of a linear accelerator for injection was initially planned will be used for manufacturing model electric magnets, according to a professor.

At the Research Institute, a model of the 250 KeV Cockcroft-Walton type preaccelerator and a model body of a linear accelerator are currently being built. However, there is no model magnet at this time. Also, development of multi-wire spark chamber, drift chamber, streamer chamber and Cherenkov chamber is in progress. There is a computer room equiped with a medium size computer of 0.5 Mbites (made in China). These devices, though some of them are quite good, will not be practically usable except for a few. For example, the pre-accelerator has 200 KeV. However, it shoots a beam of 250 mA, and 2.5 $\pi$ mm m rad (the configuration of the electrodes is of the Pias type). The acceleration tube is inside the $SF_6$ tank. However, in actual experiments which use high voltage of about 750 KeV, the present method of using silicon rectifiers must be changed to one using selenium rectifiers.

The model body of the linear accelerator is treated with electric gilding (made in Shang Hai). The surface is well done, but there are some problems in manufacturing precision. Also, actual accelerator tubes are probably made of clad plates.

Concerning the experimental apparata, the pulse source of the streamer chamber is 300 KV (the designed target is 400 KV) and 10 ns. It produces an accurate voltage. However, other large size chambers and electronics have to be worked out in the future.

A larger size computer is necessary and they are considering importing M series computers from Japan. The peripheral equipment, such as card readers, must be provided in the near future.

Generally speaking, as seen in other reports, the researchers are eager and the work attitude is very positive. However, most of the work seems to be paper work.

Work on magnets, high frequency accelerator devices and control systems are being done in cooperation with other factories we have inspected.

Overall, it is clear that China is pushing the present project with full force. The government announcements with photographs posted in the central area of Peking and parks also had articles about research done at the High Energy Research Institute. The Chief of the National Science and Technology Committee, Vice President Hoki, told us in our interview that the reason China is so keen in pushing the present project of high energy physics is not only because she recognizes its academic importance but also she aims at rapid progress of general science and technology in China via the construction of this accelerator.

4) General comments

Judging from the willingness, hard work and progress of present plans of the accelerator construction, it is certain that China will complete the 50 GeV proton synchrotron in the near future, even if she cannot meet the target date of 1982. Chinese scientists and engineers have sufficient background for accomplishing this project.

However, the most important points for quick construction of a good accelerator are the following three points:

(1) Above all, as many researchers as possible should work for construction of the accelerator by actually participating in the construction and accumulate experience. It is difficult to obtain experience for building real accelerators by reading literature and doing paper work. Also, if you introduce accelerators made by other workers you cannot use them effectively, even if you can obtain good accelerators from abroad.

At this time, they do not have any model magnets. If magnets are made in factories in Peking, it will take until February of the coming year. The Chinese seem to be considering contracting with U. S. manufacturers. However, based on our experience, it is important to make them by yourselves, even if they are not as good, to obtain experience in manufacturing and also establish techniques for measurement of magnetic fields. Without this actual experience it is impossible to build good accelerators.

(2) For this purpose of accumulating practical experience, the shortage of measurement equipment seems most crucial at this time. These measurement devices may be difficult to obtain domestically. However, they can import quite good devices from foreign countries such as Japan. Also, special instruments, such as devices for magnetic field measurement, can be manufactured at the factory of the institute or in the research laboratory.

In order for them to be able to use these measurement devices fully, it is important for them to obtain these instruments as early as possible and to actually use them. These measurement instruments are necessary not only for testing the functioning of parts of the accelerator after its complete operational adjustment and experiments, but also for constantly checking the precision of manufacturing work in the process of accelerator construction.

(3) Construction of an accelerator and high energy experiments require team work and, like an orchestra, each of the members has to cooperate with others under one conductor in their fields of expertise in order to create the harmony of the entire project.

For this purpose, the research system in China, though it has been improved after the purge of the Gang of Four, is not sufficiently functional. For example, persons in charge of designing the accelerator and in charge of its manufacturing are not quite independent. This can cause a problem. Also, information exchange between departments is not sufficient and, as a whole, it lacks coordination. Therefore, some parts are advanced and others are far behind in progress and balance is lacking as a whole.

We often heard from the Chinese themselves saying that China is inefficient. The main cause, for example, in the case of building an accelerator, is organizational problems.

The above statement is a general comment and the author explained it to many leaders he met in discussions. The Chinese leaders seem to realize these points quite well and concerning their request for cooperation with foreign researchers, they seem to be trying to limit it, contrary to the earlier trend of total dependence and limitations in certain areas partly because of the budget.

## 2. Technological exchanges at the Ranshu Modern Physics Research Institute

Yasuo Hirao, Professor
Nuclear Research Institute
Tokyo University

I visited the Ranshu Modern Physics Research Institute from March 4 to March 8 and presented the following lecture. On March 5, I gave a two-hour lecture entitled "Review of High Energy Heavy Ion Science and Possibilities of its Application" at the Ranshu Physical Society Meeting. Recently, high energy and heavy ion physics has attracted world-wide attention in many fundamental and applied research fields. Especially nuclear physics researchers in Japan realized the importance of this field from the early days.

In collaboration with solid state physics, radioactive chemistry, biology/medicine and other fields, they have been making progress in research and improved facilities.

In the field of nuclear physics, when viewed historically, research in the past was concentrated on studying nuclear matter at normal temperatures and densities. The research of high energy heavy ion will involve many new research fields, especially the study of nuclear matter at high temperatures and high densities. If the collision speeds exceed sonic speed inside the nucleus, the nucleus has a high density and generation of shock waves is expected. This is called the supersonic region. If the collision energy is further increased, one enters the region where many neutrons are created. Meson condensation, meson cooling and creation of multi-hyper nuclei become possible. Also, through reactions of these unknown heavy ions, there may be a possibility of creating ultra-heavy elements.

When we examine its practical applications, there are several epoch making events related to the fundamental research, such as the Okolokov effect in solids and creation of quasimolecules. I explained them with several examples and explained them again by showing two typical applications for the future.

In the near future, applications of heavy ions to the medical field will be realized. Compared to proton and α-particles, the scatter of flight distances of neon particles from carbon is rapidly reduced and very clear photographs can be taken. This is the reason for clinical interest. Also, its energy characteristics show a sharp peak at the end of the flight and its oxygen effect is small and biological effects are large. Therefore, it can be used in local irradiation of biological bodies and effectively used in clinical treatment. Also, since the positron emitter, which is generated in the processing of passing through the body, appears near the end part of the irradiation beam, one can use a positron camera and take pictures immediately after irradiation and confirm the condition of the irradiation. Because of these advantages, it will become an indispensable device for cancer check-ups and treatments.

Next, I will talk about the use of high energy heavy ion beams generated by nuclear fusion which has attracted attention as a future energy source.

By giving a large amount of energy in a short period of time to a small pellet of deuterium and triterium and causing compression and explosion, and by increasing its temperature to $10^{\text{[illegible]}} \sim 10^{\text{[illegible]}}$ degrees, we attempt to induce implosion -nuclear fusion. As the ignition beam, lasers, electrons and heavy ions are being considered. I discussed their merits and demerits and gave an introductory lecture on the structure and scale of the heavy ion accelerator used for this purpose. After the lecture, I received many questions about large and intense neutron beam sources and application of radiation research in Japan. There were about 200 in the audience and the meeting hall was at Yugi Hanten, Ran shu.

March 5. Inspection of various research facilities at the State Modern Physics Research Institute. The institute has a standard size cyclotron (made in the USSR, diameter 1.5 m) and other facilities are mostly accessories of the cyclotron. The cyclotron is currently being repaired and not operating. Also, there is a plan to remodel this cyclotron to a 1.7 m sector focusing type cyclotron. However, we should note that the present cyclotron has already been used for accelerating heavy ions, such as carbon, and many papers have been published. In addition to ordinary scattering chambers, helium jet transport devices for the study of radioisotopes of short life is being manufactured here. The electronic circuits and computers are made in France, though not sufficiently good.

We should notice that as a future project, preliminary study of a ring cyclotron is in progress. The structure is such that heavy ion beams from the sector focusing type cyclotron (diameter 1.7 m, the K value of 69) remodeled from the first model, is injected in the first period of the study and in the second period of study, heavy ion beams up to uranium produced by a tandem Van de Graaf unit made in the USA, will be injected. The main accelerator has the K value of 450. It can accelerate up to 112.5 MeV per nucleus up to argon, and 10 Mev per nucleus for heavy uranium. It consists of four electromagnets of about 500 tons each. Currently, two model magnets (1/4, the angle between poles 52°) are under construction. Accurate magnetic field measurements of these models are being carried out including mutual interference effects. Models of almost real size of the high frequency accelerator are also being constructed and their functions are being measured. They are almost identical to the GANIL plan currently under construction in France and the plan prepared at the Rikagaku Research Institute in Japan.

Although I did not know it until the recent visit, the 1.7 m cyclotron remodeling plan is almost the same as the one the author made for the INS-SF cyclotron which was designed and manufactured at the Nuclear Research Institute of Tokyo University. I said that our plan was extensively referred to in their plan. The outline of this research institute is given below:

| | | |
|---|---|---|
| Start | 1963 | a 1.5 m$\phi$ cyclotron was imported from the USSR. This is currently being remodeled. |
| | 1973 | A Cockcroft-Walton device of 600 KV was set up. Neutron physics for atomic power generation was studied. Presently, it is used as a neutron source of intensity of 3x11$^{11}$ particles/sec and used for cancer treatment and agriculture. |
| Staff | about 400 | Five departments (heavy ion physics, accelerator and measurement techniques, electronic circuits and computer, isotope separation and applied research) |

The lecture at the Modern Physics Research Institute given on March 6.

1. Report of summaries of the neutron project at the Nuclear Research Institute of Tokyo University, about 2 hours.

2. Report on design and construction of the INS-SF cyclotron. About 2 hours.

Especially, in the latter lecture, many eager questions were asked since they are currently constructing a cyclotron of the same type as I mentioned before. About 10 people of the design group visited me at my hotel in the evening and we had discussions in detail. I supplied many reference materials I had carried from Japan.

Inspection of Kokuka Kyo Dam on March 7.

In a deep mountainous area of altitude 2,000 m and about 150 km from Ranshu city, a large scale dam was constructed starting in 1964 by stopping the upstream flow of the Yellow River. The dam has been operating since 1969. The entire project was completed in 1974. The dam is of a large scale, having the maximum output of 1.25 GW. Its hydroelectric power generator was a domestic product made in Harbin. We went upstream in the artificial lake by a motor boat. The lake is huge and its length is about 50 km and the water level difference is about 20 m (I might mention that the person in charge of this hydroelectric station is a woman).

The overall impression of Ranshu is a yellow mountainous area without trees and grass. The city also gives an impression of remote areas covered with fog and yellow dust. It is a narrow and long city along the Yellow River. However, the city is on its way of development and, as described before, in this remote area, the Modern Physics Research Institute was built and it was impressive to see their efforts of modernization.

The researchers at the Ranshu Institute must have had the same impression. Japanese physicists did not visit the site until February of this year. It was open to them very recently and including the author, only three physicists have visited the place.

In the following, I describe technological exchanges after the author returned to Peking from Ranshu.

## VISITS TO PEKING-SEIKA UNIVERSITIES ON MARCH 9

Visitor group members: Hirao, Kondo and Masaike
Seika University side: Chorei and other four members (vice chairman of Processing, Physics Department).

In the beginning, Professor Cho gave the following explanation. During 1911-1949, this university was not a large scale university. In those days, there were three departments, Technology, Science and Agriculture.

In 1952, the university became a technological, general university. Later, the number of students increased and presently, there are about 7,000. During the period of 1949-1965, 36,000 students graduated from this university. During 1966-1976, the university suffered great damage and currently is recovering from the damage.

The university consists of 12 departments (Archeology, Fluid Engineering, Mechanical Engineering, High Pressure Devices, High Frequency Engineering, Electronics Engineering, Power Electric Generation, Electric Engineering, Physical Engineering, Industrial Chemistry, Atomic Engineering and Automation Engineering).

The primary effort at this time is to purchase a large scale tandem Van de Graaf. 15 accelerator researchers, 35 nuclear physicists and 6 solid physics researchers are involved at present. However, if the above mentioned equipment was bought, more workers will be involved.

After the above explanation, we inspected the university. The main areas are the computer rooms for education, devices for laser and development of liquid crystal materials. However, the level is not high and to our regret, we could not see the facility for nuclear physics experiments since it had not been repaired from the past damage. This university gave an impression of incurring serious damages caused by the cultural revolution.

Lecture presented at the High Energy Physics Research Institute on March 10.

PRESENT STATUS AND THE FUTURE PLAN OF THE ACCELERATOR FACILITY AT THE NUCLEAR RESEARCH INSTITUTE OF TOKYO UNIVERSITY (Materials supplied separately and attached material "summary of the numatron project").

Reference materials: 20 Year History of the Nuclear Research Institute, A Guide to the Nuclear Research Institute, Annual Report 1976, 1977, the Numatron Project, NUMATRON, Numatron and Heavy Ion Technology which involve unknown sciences.

Participants: About 100, including Professor Shu Kogen.

I met the director, Cho Bunyu, and several other members on March 12. The summary of the meeting is given below:

1) Expression of gratitude for the cooperation of the Nuclear Research Institute by a member of the Chinese Research Institute was given.

2) Wanted to know the intention of the Nuclear Research Institute about the future cooperation.

The main points stated by the present author are:

In the past, the Nuclear Research Institute took a position of giving aid along the lines of cooperation and exchanges agreed upon between the Chinese High Energy Research Institute and the Japanese High Energy Research Institute. If China considers the situation useful in the future also, we are ready to help her. Rather than making short visits from Japan, a small number of people from Japan should stay for an appropriate length of time and learn about the accelerator and related technologies. In this case, the plan should be made through the same channel which handles the cooperation of the above mentioned two research institutes. In order to avoid confusion, a clear line of authority should be defined.

After the meeting, we inspected several facilities. To be honest, the preliminary research has just begun and the balance in the entire research activity has not been obtained. For example, a model for a streamer chamber was already made, but a model for the main ring electromagnet is still not ready. Also, guages for high energies are not available at all. Work shops and machines of a surprisingly large scale are ready but those machines are not necessarily appropriate and the numbers are not sufficient.

After the inspection, we had some spare time. The author emphasized the importance of application in the field of accelerator science and especially elaborated the significance of progress in the applied fields of heavy ion science.

3. The present status of high energy physics in China.

Motoo Kondo, Professor
High Energy Physics Institute
Department of Education

Report of inspection of the Peking communication device factory.

1. The factory is located about 10 km north of Peking. The area of the factory is 210000 $m^2$, and the work area of the building is 60000 $m^2$. The total number of workers is 4000, out of which 400 are technical staff.

2. Almost all of the shortwave broadcasting equipment in China is manufactured here.

3. The factory is classified into facilities for parts manufacturing of low power electric circuits and high power electric circuits.

4. We first inspected the part of low power electric circuits.

We saw machines such as frequency modifiers (images and voice), automatic phase control circuits and automatic frequency switching devices. However, the number of workers is small and the factory looked rather inactive. We did not see the atmosphere of active production.

Next, we saw the part of high power electric circuits. The factory is rather large and had many machines waiting for finishing work. The scale of the factory is comparable to that of the broadcasting equipment factory of the first class companies in Japan. The equipment in process includes the following:

| | | |
|---|---|---|
| 400 KW, 3.9 - 18 MHz, Broadcasting unit | | |
| 120 KW S.S.B. (single side band) | 3~30 MHz | transmitter |
| 30 KW S.S.B. ( " ) | | |
| 10 KW | 50~90 MHz | TV broadcasting unit |
| 300 KW | 167~230 MHz | TV relay |
| 1 KW | 27 MHz | test equipment for cancer treatment |

Except for a few minor points, such as lack of smoothness in the shape of the containers and mechanical structures, the technical level in this field seems considerably high. We saw quadrupole vacuum tubes and large scale vacuum condensers made in China. They are comparable to those in other nations. It seems that, as a national policy of China, broadcasting is regarded as an important field. Since the frequency band of the Chinese 150 KW accelerator is the shortwave band, the above mentioned points will be very useful for construction of the high frequency accelerator.

2) Lecture (March 6)

After Mr. Kimura's lecture, I gave a lecture on the facilities of the High Energy Physics Research Institute in Japan.

I used slides for explaining the tunnels in which the accelerator was placed, the support structure of the large laboratory (the size of the support pile and the structure of the steel enforced concrete) and the condition of the soil bank for shielding radiations. Then, I explained the distribution of the electric power in the institute using a skeleton figure. Also, I explained the average consumption of electric power and cooling water in the institute.

The slides for the automatic temperature controller of cooling water, the air conditioners and the exhaust device of waste water were not ready. We ran out of time and I omitted those explanations.

Since the above lecture is not directly related to acceleration of particles and experiments, I did not have many questions. However, after the talk, some engineers in charge of the facility requested copies of the reference materials.

3) Lecture (March 7)

I gave a lecture concerning the high frequency acceleration part of KEK (abbreviation of the High Energy Research Institute) synchrotron (booster and the main ring).

First, I explained the main electric power part, acceleration chamber and the low electric power part. Also, concerning the present beam acceleration, I reported on separating the state to injection, acceleration and extraction. Then, I explained the main ring. I omitted the explanation of the main electric power part which had the same structure as the booster and gave a detailed explanation of the beam scattering in the transition to the lower power part. The time for the lecture was insufficient partly because we had troubles with the slide projector in the beginning.

4) Discussion (March 8)

The discussion was mainly concerned with the main electric power part of the high frequency accelerator. The Chinese side is considering the so-called Clad method for manufacturing the ferrite cooling plate which is to be placed in the acceleration chamber. We had considered this method before. However, we abandoned it since there were some difficulties in connecting the inlet of cooling water. When we explained this point, they answered that they had not found solutions so far. Many questions were asked concerning the large power transistor made in Japan. This is used for the ferrite bias power source. I tried to group available data as much as I could.

Also, concerning the method for determining the wave pattern of the acceleration voltage of the booster, many high level questions were asked and discussions were quite heated. In addition to these, we had questions regarding the operational mode of the power amplifier, cooling of the power tubes and the contact between the ferrite and the cooling plate. In general, they seem to have done a thorough study of literature and sufficient paper work.

5) Discussion (March 10)

On this day, we had discussions regarding the low power electric circuits of the high frequency acceleration part. First, a question regarding control of quadrupole vibration of the beam was asked and it took some time to answer. After my explanation, I emphasized that although control of multipole vibration was important, it was still a secondary problem and the main point was to accelerate particles to the end even if it was weak. The Chinese members showed a forced smile but nodded their heads. Other questions were related to generation of frequency functions by computer control, the principle of tracking filters and types of phase detectors, and time ran out quite quickly.

In this discussion, there were no questions which missed the mark and they gave me an impression that they had reached a considerably high level.

6) Conclusion

In the field in which the present author specializes, namely, high frequency acceleration by accelerators, the technologies of broadcasting and communication devices can be used as the technological basis for the former. Their level in this field seems to be sufficiently high. Also the knowledge of accelerator scientists and engineers in this field seem to be sufficient for the construction of accelerators. However, there is one problem. It is that the level of the accelerator scientists and engineers seem to be limited to deskwork and discussions. An accelerator is a real piece of experimental equipment. They should start to build a real accelerator even in a scaled down model, and accumulate experience by trial and error.

There is a considerable imbalance among each group working for the accelerator and also several different opinions regarding the process of construction. I must say that construction of the Chinese accelerator will encounter many difficulties in the future.

4. Report on research exchanges at the Chinese High Energy Physics Research Institute

Yoshitaka Kimura, Professor
High Energy Physics Research Institute
Department of Education

During my stay in China, I exchanged technical information with Chinese researchers at the High Energy Physics Research Institute for about 15 hours. The theme of the technical exchange included the following five points they had communicated to the Japanese side in advance.

1. Concerning the 12 GeV proton accelerator main synchrotron at the High Energy Physics Research Institute (KEK), its structure and operational functions.

2. Extraction of beams from the synchrotron.

3. Errors in setting the synchrotron magnet and their measurements.

4. Non-uniformity of the magnetic field and its correction and beam dynamics during acceleration.

5. The entire design of the Chinese 50 GeV proton accelerator and examination of its parameters.

The exchange was done in English in the Japanese speaker side and Chinese interpreters simultaneously translated into Chinese. There are very few Chinese researchers who can understand and speak English (especially due to effects of the Cultural Revolution, young researchers can hardly understand English). We had an impression that the language problem was a hindrance to the exchange. Because we needed interpreters, it was inefficient timewise and also, we were not certain whether interpretations were always accurate or not. We could not avoid a feeling of "scratching the foot from the bottom of the shoe". We had interpreters in our side also and we could have done the exchange in Japanese. However, technical lectures use many specialized technical terms. Therefore, this is also difficult to do. However, writing key words of important topics in Chinese characters on the blackboard is useful in improving understanding. For the lecture, we could use a 36mm size slide projector and an overhead projector.

In the following, we summarize each of the topics:

Theme 1. This is to give an introduction to the structure and operational functions of the KEK synchrotron. The content was already presented elsewhere.

Theme 2. Regarding the beam extraction system used in KEK, we explained in detail its manufacturing method, functions, and results obtained in actual operations and had a question and answer session. As a result, we confirmed mutually that the Chinese 50 GeV accelerator had the following design problems:

(1) In the structure of the present magnet for the synchrotron, the half integer betatron resonance method may cause a severe instability of beam.

(2) On the other hand, the 1/3 integer betatron method requires an extremely high accuracy of the magnetic field and is difficult to extract large beams.

(3) Since the straight part of the beam extraction is short and the side yolk of the quadrupole magnet is thick, the supplementary magnet for beam extraction suffers from a severe demand, and its manufacture has some problems. In order to solve these problems, we have to either change a part of the design or develop new techniques.

Theme 3. We reported on the accurate attachment of the KEK synchrotron magnet along the circular orbit and its error measurement, correction of non-uniformity of the magnetic field by using supplementary magnets and also our unsolved problems concerning the beam stabilization. After that, we mainly discussed the method of manufacturing magnets, causes of irregularity in the magnetic field and methods of its correction. One of the most important problems in the Chinese 50 GeV accelerator design is that the magnetic field intensity at the beam injection is usually very low, only $\sim$200 Gauss. At KEK, they chose 1,450 Gauss. Therefore, we cannot avoid irregularity of the magnetic field caused by the residual magnetization. Also, in the present design, the negative ion beam injection method is being used. Therefore, the injection time is long and it is doubtful whether the beam can be kept inside the accelerator without a loss during that time. However, if we try to improve this point, the entire design of the accelerator must be drastically changed and this is quite debatable. At this time, we can only suggest that a model magnet should be built as early as possible by measuring the distribution of the magnetic field, selection of steel materials, optimization of the ball-shape and establishment of related technologies should be done.

Theme 4. We explained the computer control method of the power source for the KEK main synchrotron magnet. This had been requested by the Chinese before we left Japan. However, questions we received after our explanation were mostly concerned with the power devices in the power source itself (for example, the structure of a large power transformer and functions of a cylister). These are not necessarily my field of expertise. Therefore, we postponed our answer and decided to answer by letter after returning to Japan and consulting with experts in these fields. This might suggest that the senior staff of the Chinese High Energy Physics Research Institute did not fully understand the intention of researchers in the laboratory.

Theme 5. This is in a sense a summary of all the discussions we had before. As mentioned earlier, there are many problems in the Chinese 50 GeV accelerator design. Some of the problems are concerned with the basic design, We discussed with the Chinese researchers about these problems, but could not reach any conclusions. Rather, I had an impression that various problems and contradictions of the High Energy Research Institute itself before construction of the accelerator were demonstrated in the discussion.

In the following I list some of these points:

(1) They have not decided how far they should depend on foreign technologies and how much they can do by themselves regarding accelerator construction.

(2) They tend to follow opinions of foreign researchers too easily.

(3) The research organization has not been established.

(4) Lack of communication between the leaders and researchers.

(5) If they want to request manufacturing of devices from companies, there are some difficulties because of their domestic situation.

(6) Generally speaking, researchers do not want to study subjects outside their specializations. Their view is narrow and inflexible.

(7) Since there are few who have experiences of building and using experimental apparata in the past, they tend to be extreme, either they worry too much in advance or are blindly too brave.

However, there are some brilliant researchers among those Chinese researchers we met this time. If a good research organization is established around those people, by making them subgroup leaders, it does not look impossible for the Chinese to build the 50 GeV proton accelerator even if it may take some time.

5. Report on a visit to the Peking Electrical Engineering University

Yoshitaka Kimura
High Energy Physics Research Institute

We visited the Peking Electrical Engineering University between 1:30 P. M. and 5:00 P. M. on March 6, 1979. The members were:

Japanese side: Director of the High Energy Physics Research Institute, Mr. Nishikawa, Professors Kondo and Kimura of the same institute, Fujiwara of Japan-China Economic Cooperation Society.

Chinese side: Mr. Karyu, head of the Accelerator Department of the High Energy Physics Research Institute, Mr. Kiyoshi Osen, interpreter.

In that institute, we met the Director (Vice Chairman of the Academic Committee) Mr. Bokusc, Research Staff, Chin Kokusen, Chief of the Business Office, Chuseimin, and heard explanations of the structure of the institute and its research work. Then we visited two laboratories where superconducting magnets and MHD power generators were being developed.

This research institute belongs to the Chinese Academy of Science. The scale is of medium size. The total number of staff is about 600 (out of which, about 400 are researchers). The annual budget of the last year is about six million yuan (about $8 \times 10^8$ Japanese yen). The institute has eight research sections. They are studying the following subjects:

(1) Application of magnet hydrodynamics (MHD power generation, etc.); (2) special electric instruments (solar energy, etc.); (3) high pressure technology; (4) application of superconductors; (5) computer applications; (6) electric discharge processing; (7) electric motors; (8) plasma application.

The superconductor room which we first visited is used for study of application of superconductors, especially superconducting magnets. The research covers a wide area including magnets for MHD and small magnets for solid state study and a part of which is a cooperative research with the Chinese High Energy Physics Research Institute. Designings and model makings of pulse magnets for the accelerator, direct current magnets for beam transportation, and large direct current magnets for a bubble chamber, etc., are being developed. For these studies, they have two helium liquifaction devices. One of them is a 20 l/h machine made here. The other was made by a Chinese company and produces 50 l/h. At the present level of research, they can only perform tests on the superconducting wire materials by making solenoid type magnets. We could see a model for coil testing regarding the saddle type magnet for a high energy accelerator. They have succeeded to generate a magnetic field of 50 $\sim$ 60 KG in the core of $\sim$ 10 cm $\phi$ in the solenoid.

In addition to this study of magnets, we saw many Chinese samples of superconducting wire materials also and could obtain some of them. These superconducting materials are made in a specialized factory in Shisen-sho and other places. (Research type factories. Study of magnets is still in the beginning stage. However, we realized that the level of research on superconducting materials is quite high and we were quite impressed. They are currently making five wires of NbTi (niobium titan). There are a variety of cables made of twisted NbTi wires and of the type fixed by blade reindium etc.

Also, as a material for the $Nb_3Sn$ (compound), they developed fine wires instead of tapes. To the outside observer, the superconducting wire material technology in China seems comparable to those in other nations. At present, the demand is only from research fields and the cost of wire materials is about 10 times more than that in Japan (since we cannot compare materials of the same quality, this comparison may not be very accurate). Finally, we quote the director, Mr. Bokuso's statement, "China has about a half of the total amount of Ni and Ti underground resources in the world. China is rich in helium. Therefore, development of superconductor technology is extremely important for China".

Next, we visited a research laboratory where MHD power generation devices were being developed. Presently, they have a device which can continuously operate at 20 kW and another which can operate at 200 kW for several minutes. They are planning to make a 500 kW unit in the near future.

Since we are not specialists in this field, we cannot make an accurate judgment on the research level and its content. However, judging from the scale of the research, the level of research must be reasonably high.

We visited Peking Electric Engineering University. The overall impression is that most of the research fields in this institute are related to energy (development of new energies and energy saving). This shows that China is positively engaged in energy problems, even to the extent that, compared to daily living standards, it seems rather excessive.

6. Technical discussions with Chinese researchers.

Akira Masaike
Assistant Professor, High Energy Physics
Research Institute,
Department of Education

Following the lecture, we had three discussions. The content of these discussions were related to elementary particle physics using accelerators, high energy particle measurement devices and development of polarized targets and construction.

First, the author introduced elementary particle physics, especially high energy experiments carried out in Japan. The author mainly explained the present status of multi-quark state studies, K-meson decay and generation of leptons by hadron collisions. Study of the multi-quark state includes the so-called Z* resonance, bariomium, di-barion, etc., and is suited for study using the energy obtained at the Japanese High Energy Research Institute. The author emphasized that by measurement of the polarization parameter, we can study a new aspect of elementary particles.

On the other hand, the Chirese are interested in study of bariomium, neutrins reaction and property measurement of new particles including charm, since these can be done immediately after the accelerator is completed. However, it will take several years before starting these studies. Therefore, they plan to do further thorough examination and start necessary preparations.

Next, concerning development of measurement devices, the drift chamber was discussed which is being studied at high energy physics research institutes in both China and Japan. China wants to develop the secondary read-out. For this purpose, she wants to refer to the development in Japan. Also, we exchanged our opinions regarding development of Cherenkov counters using aerojell.

The author also explained the circumstance and present status of development of a large solid angle spectrometer (TELAS) including a small target for the spectrometer with a large solid angle. This will be a reference for China's future projects.

China is developing a streamer chamber. Therefore, they are planning to study construction of spectrometers using a streamer chamber. Concerning the bubble chamber, I explained about the 1 m bubble chamber in Japan. I was told that they decided to build a rapid cycle bubble chamber in China. We decided to carry back questions asked by the Chinese side regarding the bubble chamber data analysis to Japan and later reply to them.

On the subject of polarized targets and their construction, I explained in detail the history in Japan and answered questions from the Chinese about electromagnets, cooling devices, polarized materials, microwaves and others used for building polarized targets.

Since development and construction of polarized targets take a considerable amount of time, we concluded that they should start preparation as early as possible. They have restrictions due to materials for the electromagnets, pumps and other equipment. However, they have investigated these points to a considerable extent. In the future, with cooperation of the Japanese, it seems possible to carry out a full scale development and construction project.

I think that this discussion session was useful since many concrete and practical points were raised in the meeting.

7. Content of inspection of the Peking Heavy Electrical Equipment factory.

On the morning of March 6, we inspected the Peking Heavy Electrical Equipment factory located on the west side of Peking city. This factory was built in 1958. After 1966, it was expanded during the Cultural Revolution. Regarding the size of the factory, it is fourth from the top among heavy electrical equipment factories in China. The total number of workers is about 6,100 (about 2000 are women). About 1/3 of the workers joined the factory around 1968 when the Cultural Revolution was going on. The total building area is 230,000 $cm^2$ and it has 18 factory buildings, several offices and design rooms. The main product of this factory is power generation devices. Especially they manufacture many large and small electric power generators for alternating current and direct current. The largest one is 100,000 KW. In addition, various facilities for power stations are also made here. Also, they design and manufacture special electromagnets in cooperation with universities and research institutes. For example, the electromagnet for the heavy proton 15 MeV cyclatron in Shiang Hai (Fukutan University?) was made in the earlier half of the 1960's in this factory, using the cyclotron in the Atomic Power Research Institute in Peking as a model.

The deflection electromagnet and quadrupole magnet used for the 50 GeV synchrotron, which is to be built at the Atomic Power Research Institute in Peking, is scheduled to be built in this factory. At present, they are designing model magnets in collaboration with the Atomic Power Research Institute in Peking.

The overall technical level is not top-notch. However, I felt that their level is at least as high as average. However, individual techniques have many problems. For example, they cannot choose the shape of the hollow conductor of the electromagnet coil as we can in Japan and the manufacturing precision of parts is not always sufficiently accurate. Also the manufacturing process is the manual type and mass production seems difficult. The efficiency of production is also a problem.

On the other hand, they seem to be overly cautious about developing magnets for synchrotrons. They seem to sometimes improve accuracies unnecessarily and also they think that a huge facility is necessary for this purpose. It is sometimes hard for us to understand their misunderstandings even after taking their inexperience into consideration.

However, generally speaking, there is a sufficient potential for technical improvement and increased production in the future. We expect a remarkable progress in several to 10 years.

## V. MEMOIRS OF THE TOUR

As an amateur, not as a high energy physicist, I would like to summarize my impression of the technical exchange of our group.

Before leaving Japan, I had the impression that the Chinese Academy of Science was the main leader of high energy accelerator construction. However, according to the head of the accelerator division of the Chinese High Energy Physics Research Institute, the design is to be done by the Chinese Academy of Science, but construction of the accelerator is carried out by the National Science and Technology Committee. In other words, designing and building the accelerator are not under one authority but divided as to design and construction, under separate authorities.

Concerning this point, not only the present author but specialists of our group also felt that this compound system was not reasonable.

When we recall that the accelerator at the High Energy Physics Research Institute of the Department of Education in Japan was completed under one authority from the design to construction, this two authority system in China has a danger of hindering a synchronized operation of the design division and construction division.

This type of trouble caused by the multiple authority system is not limited to the accelerator. Even among the Chinese staff who took care of our group, could one see such symptoms. The office of the Chinese Academy of Science, the office of the Science and Technology Committee and the office of the High Energy Physics Research Institute separately sent some of their staff, but communications among them were not quite smooth.

For construction of the accelerator, I feel that an organization which has executive authority such as the Science and Technology Committee rather than the Academy of Science alone will be able to operate more effectively.

Construction of the accelerator requires many high quality parts in large quantities. If the Peking Heavy Electric Factory and the Peking Broadcasting Equipment Factory which we visited are asked to manufacture them and if they refuse, the High Energy Physics Research Institute cannot force them to do this. Therefore, the Science and Technology Committee which has the executive power is trying to mediate between the research institute and collaborating factories and synchronize efforts for construction of the accelerator.

In this area, there seems a dilemma of the Chinese system of two authorities. The staff of the High Energy Physics Research Institute is selected from universities and research institutes all over the nation and the quality of the staff is very high. However, the biggest problem is how to organize activities of these excellent people and concentrate their efforts on the construction of the accelerator.

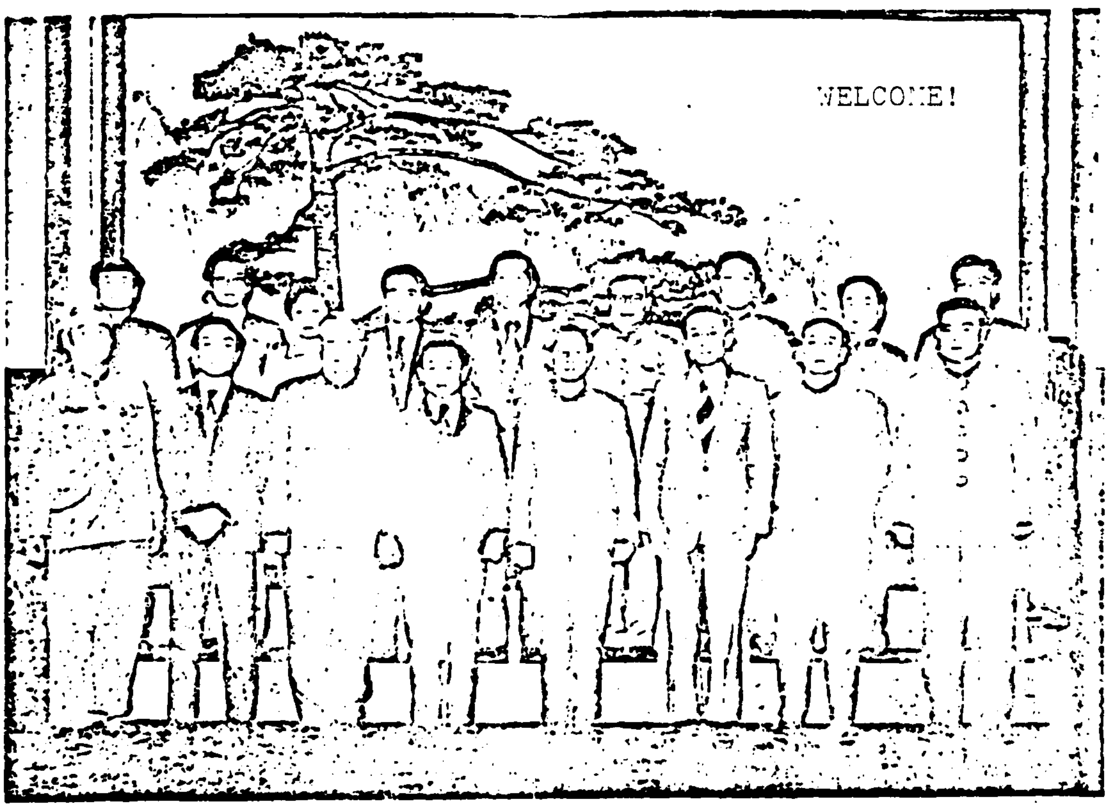
Even inside the institute, there are a group of people who want to make as many parts of the accelerator as possible domestically and another group who want to import many parts and guages and construct the accelerator as early as possible. These two groups have not been able to reach agreement so far.

Therefore, the area scheduled for construction of the accelerator as reported in Japan is still only a scheduled area. The actual construction work has not begun at all. In Japan, it was reported that the construction had already started. However, when our group visited the area specified for the construction, we could see only a wide open snow covered field. Also, the blueprint of the accelerator has not been finalized yet and there are several alternate blueprints.

These points are expected to be thoroughly investigated after Mr. Rin Sosho visits Japan, the U. S. and Europe. He heads the Chinese High Energy Physicst group.

As a whole, construction of the Chinese accelerator is still at the paper work stage. Construction of this accelerator is significant for China not because of its indirect effects on technologies but rather because of political influences. According to a Chinese researcher, they were planning to build 10 GeV accelerators in the beginning, but the plan was changed to 50 GeV by an order from the upper leading group.

Finally, we can see how eager the Chinese are to develop high energy physics from the fact that Vice Premier Hoki suddenly interviewed our group at night on March 8 and talked to the group leader, Mr. Nishikawa, for more than three hours about scientific and technical problems. As a proof of the positive attitude of the Chinese towards construction of the accelerator, I quote below an article of Vice Premier Hoki's interview with our group. This was reported in People's Daily on March 10, 1979.




INTERVIEW WITH VICE PREMIER HOKI

## VI. ACCOMPLISHMENTS OF THE PROJECT

Sending a Japanese high energy delegate to China is significant in the sense that technical exchanges between two nations have developed to truly mutual exchanges.

In recent years, China sent four representative groups to Japan, but our group was the first Japanese sent to China.

As I mentioned before, construction of the accelerator in China is still only at the stage of planning on paper. However, it was timely for both China and Japan that our group visited China at this time.

Since our group explained technologies and experience related to accelerator construction after understanding the situation in China, we expect that our visit will be very useful for the Chinese in future planning. The significance of our visit is not that we taught technical know-how to China, but that we reached mutual understanding that the Japanese High Energy Physics Institute of the Department of Education and the Nuclear Research Institute of Tokyo University will cooperate in training the Chinese research staff over a long term.

Concretely, the High Energy Physics Research Institute will accept 5 ∿ 6 Chinese researchers who will visit for the period of a half or one year. Also, the Nuclear Research Institute of Tokyo University will accept 2 ∿ 3 persons for a half and a one year period.

This must be a very effective cooperation for China which is trying to train scientific and technical staff with full force, even though the number of people who visit Japan is rather small. This will help strengthen the foundation of scientific and technical exchanges between the two countries.