KEK News

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Nobel Prize 2008 • KEK now and more

High Energy Accelerator Research Organization

2008 Nobel Prizes for the Outstanding Contribution to Particle Physics

Our warmest congratulation goes out to Makoto Kobayashi, Former Director of Institute of Particle and Nuclear Study of KEK, Toshihide Maskawa, Professor emeritus of Kyoto University and Yoichiro Nambu, Professor emeritus of University of Chicago, for their 2008 Nobel Prize in Physics.

I should first mention about the Kobayashi-Maskawa theory because we are proud of having contributed to prove the correctness of their theory through our Belle experiment. Nobel prize is awarded to theory only if it is proven to be correct by experiments. Kobayashi and Maskawa proposed a mechanism for CP violation in the weak interaction in 1972. They pointed out that a tiny amount of CP violation, a combination of charge and parity imbalance in neutral K meson decays, could be attributed to the existence of six kinds of quarks, when only three quarks were known to exist. Their seminal work has become a major pillar of the standard model of elementary particles, and their landmark paper has been cited more than 5000 times since then. They directed their attention to the spontaneously-broken gauge theory well before the theory was widely accepted. In relativistic quantum field theory, CPT symmetry, a combination of charge, parity and time, is automatically conserved, while other discrete symmetries, namely C and P symmetries, are maximally broken in the weak interaction. On the other hand, it has long been believed that the weak interaction respects CP, which is the symmetry under the exchange of particles and anti-particles, until a tiny CP violation was discovered in neutral K meson decays in 1964. Kobayashi and Maskawa investigated whether the CP violation can be understood in the context of the gauge theory of weak interaction, and found that a possible way to make sense is to assume the existence of three more unknown quarks, namely charm quark and the ones in the third generation.

Discovery of charm quark in 1974 was followed by the discovery of bottom quark, the 5-th quark, in 1977. These established the three generation picture of the quark model. The 6-th, top quark, turned out to be extremely heavy in comparison with the rest of the quarks and leptons, and was finally discovered in 1995 at the Tevatron collider in Fermilab. These successive discoveries of quarks have given strong support to the model proposed by Kobayashi and Maskawa.

The nature of CP violation can be precisely inspected by measuring the decays of the bottom quarks. At KEK in Japan, a B-factory was built in order to elucidate the mechanism of the CP violation in the standard model, under a hard competition with another B-factory being built at SLAC. In 2001, both SLAC and KEK convincingly showed that the CP symmetry is broken in the B meson system as predicted by the Kobayashi-Maskawa mechanism. This was followed by many other measurements of the B meson decays at the B factories. By now, these very precise measurements experimentally verified the Kobayashi-Maskawa model.

Professor Yoichiro Nambu introduced the concept of spontaneous symmetry breaking.

The first success of this theory was that it revealed the existence of a hidden symmetry behind the force among nucleons, which at that time seemed to be too complicated to describe theoretically. Nambu's theory explained the reason that the necleon acquires a mass by introducing a mechanism of broken symmetry. The presence of the light meson, now known as the pion, is the evidence that the hidden symmetry does actually exist and is broken spontaneously in the vacuum.

Later, the concept of spontaneous symmetry breaking turned out to be essential in the Standard Model of elementary particles, that describes the fundamental forces among elementary particles. The origin of mass of particles is now understood to be a consequence of a broken symmetry in the Standard Model. The existence of the Higgs particle, that is predicted by the Standard Model, is now being tested by the Large Hadron Collider (LHC) experiments, for which KEK has been significantly contributing to.

Professor Nambu also proposed other innovative ideas in elementary particle physics. They include the formulation of string theory, the introduction of "color" degrees of freedom that binds quarks together to form a nucleon. In addition to his outstanding contribution to the theory of elementary particles, he has also been contributing to the evolution of high energy physics in Japan, that we greatly appreciate.

We are extremely happy that Professors Nambu, Kobayashi and Maskawa have made their outstanding contributions to the particle physics which surely deserves the Nobel Prizes.

Atsuto Suzuki, KEK Director General

Dr. Kobayashi at KEK

Belle results lead to Nobel Prize for Kobayashi and Maskawa

As described in the previous article, Kobayashi and Maskawa's explanation of the origin of CP symmetry violation (KM theory) predicted the existence of six quarks. Although the sixth quark (top quark) was discovered in 1995, it was not enough to prove that the KM theory is the correct theory for CP violation. The KM theory also made a distinct prediction that large CP asymmetries could be observed in the decays of particle containing a b-quark (called *B* meson). Therefore, observations of CP violation in *B* meson as KM theory predicted is a key point of its validity. The B-factory experiment Belle and KEKB asymmetric-energy e^+e^- (3.5 on 8 GeV) storage-ring collider were built to prove the KM theory as one of the primary goals (so as BaBar experiment at PEP-II accelerator in U.S.A).

Since the decay modes which the KM theory predicted the occurance of large CP violation only in very small fractions, large number of *B* mesons should be produced. Also, *B* mesons should be produced with enough velocity in order to measure decay time through measuring flight length, which is essential to measure CP violation. These required a new accelerator with asymmetric-energy and much higher luminosity, which did not exist so far; the new accelerator and experiment are quite challenging ones.

The Belle experiment (Fig.1) and KEKB started operation in 1999 and in 2001 the large CP violation was observed in the neutral B meson system, which is the first observation of the CP

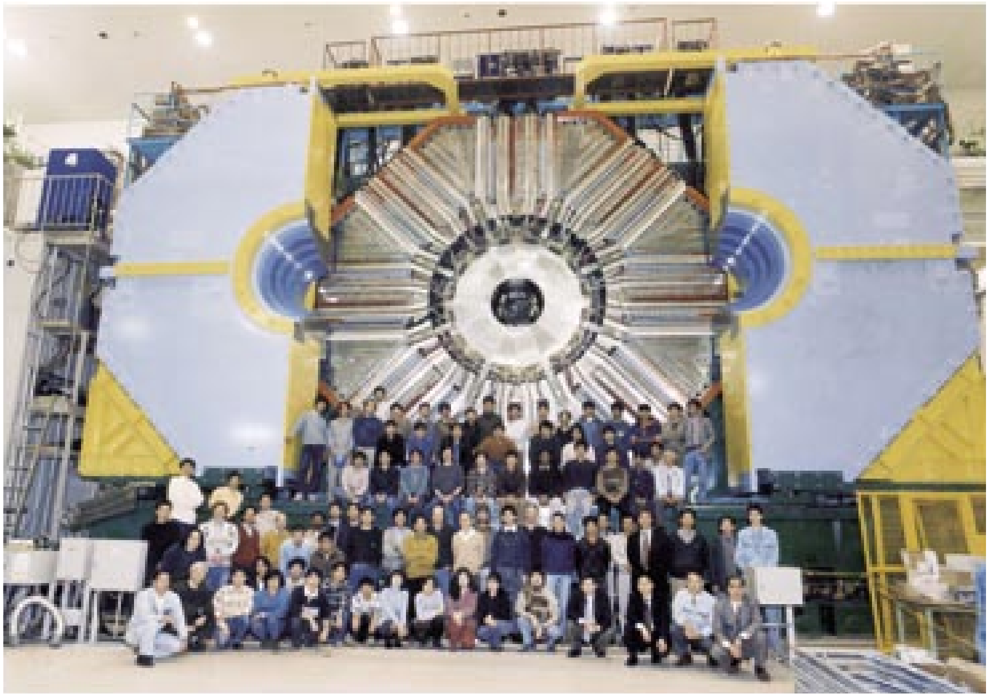


Figure 1:
The Belle detector and collaborators, taken when the detector assembling was completed.

violation other than in Kaon system and provided a compelling evidence of validity of the KM theory. This result is based on a data sample of 31 million $B\,B$ pairs and about 1300 signal B decays (B^0 mesons decay to two particles named as J/ψ and K^0). The CP violation appears as difference in decay time distributions between B^0 meson and anti-B^0 meson (see Fig.2 as a most recent measurement)

Since then, KEKB accelerator has improved its luminosity and the Belle experiment has accumulated much more data. Many new results on the CP violation in other B decay modes and decay properties of B decays provided conclusive evidences for the KM theory.

We are really happy to have heard the statement of Prof. Maskawa at the first Nobel prize interview that the most important thing for him is that their theory is proven to be correct by the experiment in 2002 and 2003, which are our results; and similar from Prof. Kobayashi when he visited KEK on the next day. This is also mentioned in the press release from the Nobel foundation and we are proud of it.

The author of this article, ***Dr. Yoshihide SAKAI***, is one of the leading members of the Belle experiment and has been involved in the CP violation analyses of B decays.

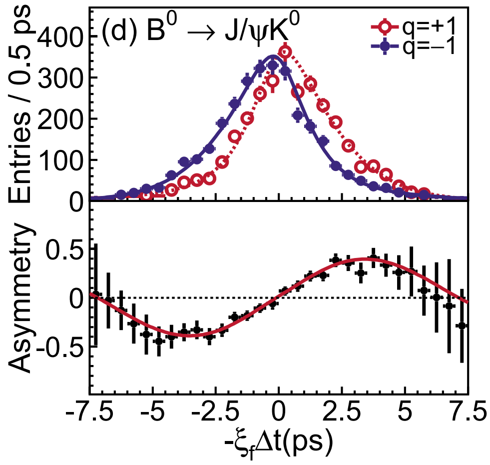


Figure 2: Decay time (Δt) distributions of decays to CP-eigenstate events for B^0-tagged (red) and $\bar{B}^0$-tagged (blue) cases. The asymmetries for Δt bins are shown in the lower plot.

The theory to predict new elementary particles

If you find an event that is not explained by the theory of elementary particles at hand, it may indicate the presence of new unknown elementary particles. This is exactly what Makoto Kobayashi and Toshihide Maskawa did when they published a paper to explain the mechanism of the CP violation in 1972. For them, the mysterious experimental results were those of Cronin and Fitch (Nobel laureate, 1980) published in 1964 that showed that the physics law is different when you go back to the past in time. This phenomenon is called the CP violation.

In their theory to explain the CP violation within the renormalizable gauge theory of weak interaction, Kobayashi and Maskawa needed the presence of the third generation quarks, namely a couple of new kind of quarks, that are now called the bottom and the top, in addition to the first and the second generation quark pairs which had been known by then. To assume the existence of such new particles was considered to be quite brave at that time, because there might be more economical ways of explaining the phenomena without adding more new particles. But, the nature does not necessarily respect theorists' logic of simplicity; in fact the new particles showed up later in 1977 (bottom quark) and in 1995 (top quark).

This was not the first time in the history of Japanese particle physics to predict the new particles. In fact, it was Hideki Yukawa who predicted a completely new elementary particle, now called the pi meson or pion, in 1935. Under his strong influence, a number of theoretical physicists were educated in Japan. Among them, Shoichi Sakata formed a unique group in Nagoya University and made remarkable contributions to the models of elementary particles, including the Sakata model that introduced the idea of composite model of nucleons, ahead of the quark model of Gell-Mann (Nobel laureate, 1969). Kobayashi and Maskawa graduated from Nagoya University and were influenced by the philosophy of Sakata. Their theory of CP violation was then developed in Kyoto University.

Nowadays, particle theorists do not seem to hesitate to introduce new particles. Indeed, many theorists are talking about the supersymmetry, that actually doubles the number of elementary particles. Whether or not this is the truth can only be decided by experiments, like what happened for the Kobayashi-Maskawa theory for which B factory experiments, BaBar (SLAC) and Belle (KEK), played the important role to prove the correctness of the theory by actually measuring the size of the CP violation and testing the consistency between the experiment and the theory. Theorists are now waiting for the data from new experiments, such as the Large Hadron Collider (LHC) and the KEK Super B Factory. They may discover the supersymmetry, or more interestingly discover another mystery! It will then be another exciting era of particle physics.

The author of this article, ***Dr. Shoji Hashimoto***, is a theoretical particle physicist working on large scale numerical simulation of Quantum Chromodynamics, the theory of strong interaction. Also interested in public relations activities of particle and computational physics.

KEK Director General talks about the Roadmap of KEK

We will reach another turning point around 2009~ 2010. At KEK, J-PARC, the high intensity proton accelerator complex, will finish the first construction stage at Tokai and experiments for material and life science (using neutrons and muons) and experiments for particle and nuclear physics (including neutrino studies) will follow.

The KEK B factory is expected to reach the targeted integrated luminosity, 1/ab, by that time. The technical design-phase report for the international linear collider, ILC, by the international collaboration will be presented up to 2010.

The PF users community is requesting energy recovery linac (ERL) R&D as the next generation light source. And the last but not the least, the international experimental program at the Large Hadron Collider at CERN, LHC, started and their first results will be expected around 2010.

Hence, it is time to prepare for the next step. KEK task force headed by Prof. Fumihiko Takasaki, the Director of IPNS, came up with a strategy plan reflecting the proposal of former DG Yoji Totsuka and requests from user communities. It is under the international review committee to look through. Taking into account of the recommendation of the review committee as well as the opinions of the relevant scientific communities, we will soon finalize the roadmap. Attached is the (not yet officially finalized) draft plan. With the finalized plan, we will start negotiating for the budget support.

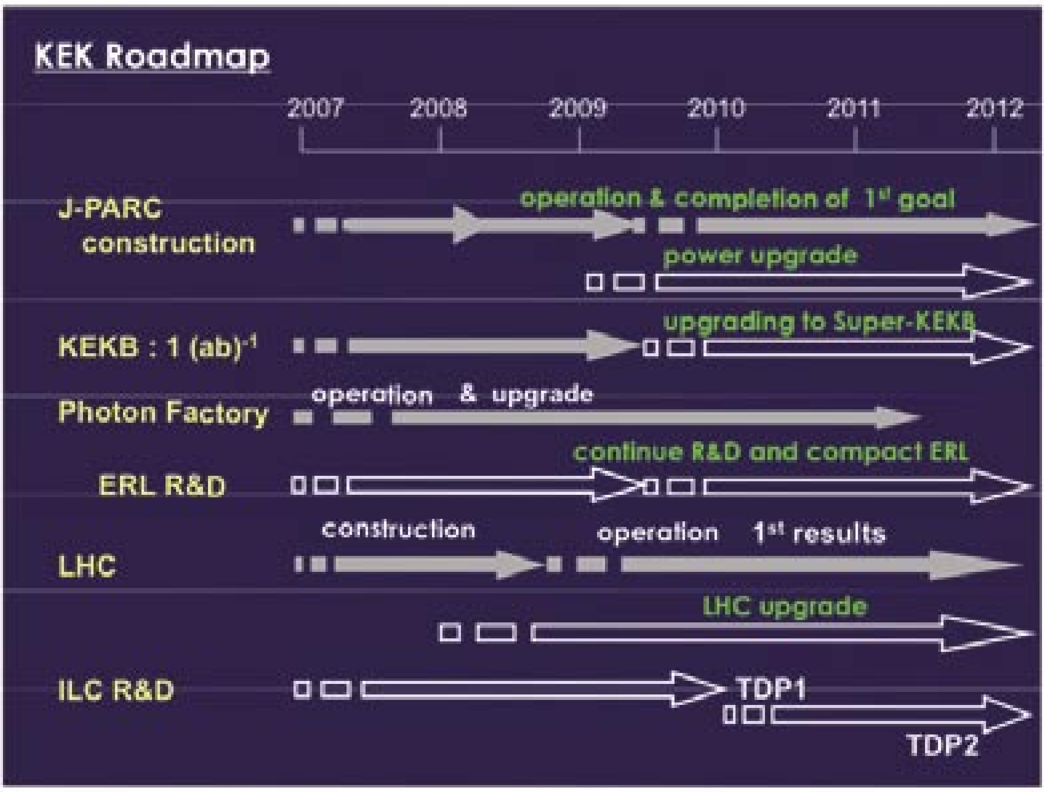
The roadmap is to make KEK stay as one of the leading research center in the world. As for J-PARC, the LHC and the light source facility, the plans are basically the same as the interim report presented by the former DG, Professor Totsuka. However, as to the decision on which direction we will be putting more effort (either for the early ILC construction or for Super-KEKB which is the upgrading of the current KEKB), the choice was left undecided in the interim report. The roadmap committee has proposed to start with the upgrading of KEKB to offer a unique research facility that will enable advanced studies on rare B decays. This will be followed by a powerful R&D program on superconducting cavities and related topics in order to contribute to the early realization of the ILC.

I am convinced to go that direction as the committee proposed.

Recently the UK government and the US government decided a large budget cut on their High Energy Physics programs. I would like to express my deep distress about this to have happened. As the size of accelerator science projects grow bigger and bigger and the time span of each project becomes ever longer, it is essential to build up globe-wide international collaborations and to establish a solid ground to support such collaborations in pursuit of the frontier science and accelerator/detector technology.

At the same time, KEK must appeal to Japanese tax payers for more supports. We should be taking part for solving various problems outside of fundamental research, such as energy and environmental problems, to show what we can do for the society. We would be collaborating with industries making good used of technologies we have invented, accumulated, or discovered, while we do our fundamental researches at the same time. We cannot just stay within pure researches only.

KEK Director General Atsuto SUZUKI



The KEK Roadmap for the next 5 years

Penguin Song
— CP violation at Belle

The Belle experiment at the KEKB B-factory has been pursuing a phenomenon called violation of the charge-parity symmetry (CP violation) since its start in 1999. KEKB is a 3-km-circumference accelerator that produces a large number of B mesons (and its anti-particle partner, anti-B mesons), and Belle is a particle detector complex where B meson decay processes are measured and recorded. CP violation, or in other words difference in the behaviour of elementary particles and anti-particles, was an utterly unexpected and unbelievable phenomenon when it was first found in 1964, and only a couple more examples have been found to date. But CP violation is no longer a mystery — it is in fact one of the fundamental basis of the Standard Model of particle physics. CP violation observed in early Belle data is one of the rare examples and has been a strong support. This year, the Belle group reported a very interesting new CP violation result in the Nature journal; and it came out with an excellent commentary article by Prof. M. Peskin, with a title "Song of Electroweak Penguin."

Penguin? Yes, Belle physicists are interested in penguins. A neutral or charged B meson is a heavy object that is made of a heavy anti-b quark and a lighter d or u quark (an anti-B meson is made of a b quark and an anti-d or u quark), and the produced B meson decays almost immediately into lighter particles. There are hundreds of B meson decay processes, and these processes have been systematically classified by "diagrams". Some of them are called "tree" when it is made of stems and branches (Fig. 1a), some of them are called "penguin" when there is a loop in the diagram (Fig. 1b, one could draw a more penguin-like diagram with a bit of imagination). The loop is made of heavier particles than the initial B meson, and brings out information (or song) of such particles. Electroweak penguin is a special case (Fig. 2), where the penguin loop emits a photon or Z boson that carries out electroweak interaction. And, we can tell that there will be a CP violating asymmetry in the decay rate if there are more than one diagrams with different complex phases for the same decay process exist. So, CP violation is a predictable piece of particle physics.

A simple example would be a B meson decaying into a charged K meson and a charged or neutral π meson. It mainly goes through two diagrams (Fig. 1a and 1b), from which we expect a CP violating difference in the decay rate. Both mesons are copiously produced as decay products, but the chance to have only one K and one π is not very large — only once or twice in a million B meson decays. That is why a huge data sample is needed. After analyzing five hundred million pairs of B meson decays collected by Belle, about a 10% CP violating asymmetry was found in the numbers of observed events between neutral B and anti-B meson decays, while initially the numbers of B and anti-B mesons are the same as they are produced in pairs. According to the classification with diagrams, the same CP violation should be observed in the charged B and anti-B meson decays since they proceed through the same set of diagrams and hence are expected to have similar properties. The observation was contradictory — the sign of the asymmetry was opposite.

Is this a failure of the Standard Model? Well, the Standard Model is not so simple since one can also think of diagrams that are not common between neutral and charged B decays. The problem here is that contributions from such sub-dominant diagrams, e.g., the electroweak penguin diagram, are too small for an explanation. Introduction of new physics beyond the Standard Model could fill this observed difference — one possible explanation is that the contribution from the electroweak penguin diagram (Fig. 2) to the asymmetry is amplified by a loop that consists of new physics particles. Physics beyond the Standard Model is believed to exist for many reasons, and finding its evidence is the most urgent theme in particle physics nowadays. So, we might have hit a goldmine! As there are too many possible new physics hypotheses with unknown particle masses and couplings, we need further evidence through different measurements in other B meson decay processes, to judge the validity of this kind of interpretations.

To give a clear answer, a data set by an order, and ultimately by two orders, of magnitude larger is in demand. And, this is our strong motivation to upgrade the existing KEKB collider and the Belle experiment to the “SuperKEKB”, to hear the penguin song more clearly.

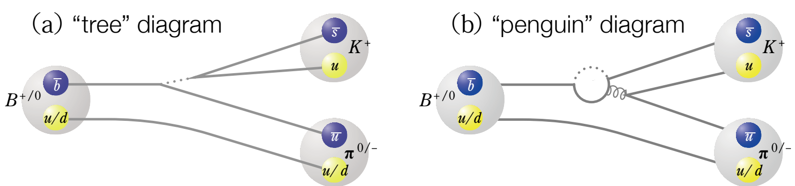
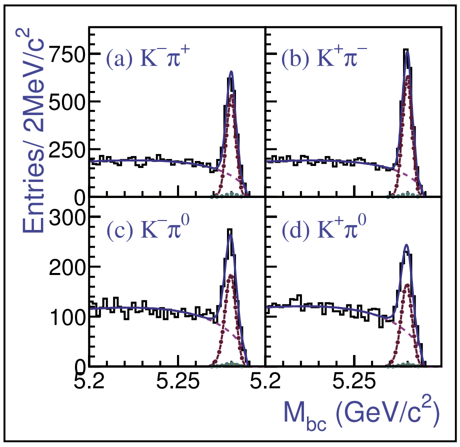


Figure 1: Two dominant diagrams for B decays into a charged K and a charged or neutral π.

Figure 2: “Electroweak penguin” diagram that appears in the charged B decay into K and π, but not in the neutral one.



The author of this article, ***Dr. Mikihiko Nakao***, is playing a leading role in the study of B meson rare decays and direct CP violation at the Belle experiment.

ATF2: An international telescope for nanometer size beams at KEK

Future electron-positron linear colliders like the projected International Linear Collider (ILC) or Compact Linear Collider (CLIC) are viewed by many particle physicists as ideal tools to probe the most fundamental constituents of matter. Complementary to hadron colliders as the successful Tevatron at Fermilab (Chicago) or the upcoming Large Hadron Collider at CERN (Geneva), ILC or CLIC could help clarify several outstanding mysteries and inconsistencies in our present understanding of physics at the Tera-electron-volt energy scale. The symmetry breaking mechanism invoked in our model of electroweak interactions to give masses to particles, or the origin of the missing mass observed in the universe, should be characterized unambiguously at a linear collider thanks to the controlled experimental conditions and precise reconstruction.

While differing in the beam acceleration technology and highest energies achievable, both ILC and CLIC require very tightly focused beams, all the way from the electron and positron sources to their interaction point, where the vertical beam sizes should become as small as a few nanometers. This is an area where KEK pursues an ambitious R&D program, attracting excellent scientists from all over the world. This program has special relevance since it can be shown that in the design optimization of any linear collider, there is a direct relation between the cost of accelerating the beams to the highest energies and the ability to achieve the smallest vertical beam sizes.

The Accelerator Test Facility (ATF) at KEK is a dedicated storage ring for beams with energies of 1.3 Giga-electron-volt, where the “emittance”, the volume over which the transverse phase space extends, is reduced to tiny values – nanometer-radians horizontally and as little as 10 picometer-radians vertically. The mechanism involved is called “radiation damping”. As charged particles are bent in the magnetic guide field, they loose energy by photon radiation in the direction of their momentum. Replacing this energy by accelerating them in radio-frequency cavities, where the electric field is aligned with the reference trajectory of the beam particles, then gradually reduces their transverse momentum. This provides a “cooling” which in competition with heating mechanisms from single particle interactions and from the stochastic nature of the photon radiation determines a steady state.

The more recent ATF2 project operates a scaled-down prototype of the final focus system needed for future linear colliders by extracting the cooled ATF beam in a dedicated transport line. The primary project goal is to establish the hardware and beam handling technologies pertaining to reliably producing and maintaining the extracted beam stably focused to transverse beam sizes as small as 40 nanometers vertically. The transport line works essentially as an optical telescope with large magnifying power. The optics involved are sophisticated as chromatic and geometric aberrations up to third order must be handled. State-of-the-art tuning and control techniques are developed to rectify imperfections, in particular to absorb variations from ground motion, power supply ripples and thermal drifts.

Instruments to measure such tiny beams are also a special challenge. A technique to measure nanometer-size beams, based on collisions with photons in an interference pattern from a laser and analyzing the Compton scattering as a function of relative position, was invented at KEK and already tried in the past. For ATF2, such a monitor will be required to work continuously to enable optimization and long-term stabilization. Another technique is used to measure the position of the beam with high accuracy, based on extracting and amplifying several resonant modes excited by the passage through a cavity. Resolutions of 5-10 nanometers have been obtained so far.

The ATF2 design and construction are basically complete, and the hardware is just now being installed. The beam line will be commissioned with first beams in November 2008 and in the first half of 2009. Dedicated operation is then foreseen for several years. A somewhat novel feature for an accelerator project is that all phases of the project – the design, construction, installation, commissioning, operation, software control and analysis tasks – are pursued within an international collaboration, with major contributors from America, Asia and Europe sharing responsibilities much as large high-energy physics experiments have learned to do it.

Besides its primary technical goals, the facility will serve as training ground for many young physicists and engineers. A particularly attractive feature in this context is certainly the stimulating international work environment at KEK and within the ATF2 collaboration, combining a strong and demanding organization, necessary to ensure high-quality and timely achievements, with a friendly and open atmosphere in which members can freely exchange ideas and know-how, find adequate support, be creative and try new ideas, or just informally join a team to contribute and learn: an excellent choice for students with a taste for challenge to thrive in the next few years !

The author, ***Dr. Philip Bambade***, is an experimental high-energy physicist at the CNRS, in France. During his career, he has had the opportunity to pursue research in both accelerator and particle physics. At present, he leads one of the European teams of scientists working on the ATF2 project.

KEK and SESAME

SESAME project was originally conceived by Drs. Winick (Stanford University) and Voss (DESY) to make a good use of the former BESSY-1 (terminated in 1991) equipment of Germany. They persuaded German government to donate the equipment and in 2002, UNESCO made this as its own project. The Director General of UNESCO (Mr. Matsu-ura of Japan) sent invitations to relevant countries to participate. There now are 7 member countries (of middle east) along with 10 countries in observer status. Responding to Dr. Winick's call for support, Japanese researchers started to help on the design and construction of SESAME. Japanese government is also reacting positively. At the moment, Japan is acting as a guest, but is expected to become an observer status country by coming fall.

KEK has been in support of SESAME from the early days. Former Director of the Photon Factory, Prof. Emeritus Sasaki, has been the initial leader for it. 10 KEK members along with 7 others visited Jordan for the "Seminar on Synchrotron Radiation Accelerators and Their Applications" hosted by Japan. It was held at Al-Balqa Applied University in Jordan. Attended were 57 students and 90 contributors from 22 countries. This seminar was very welcomed.

JSPS (Japan Society of Promotion of Science) accepted our proposal of SESAME Support Program for three years starting from fiscal year 2007. This program consists of two parts; One of them is to invite researchers from SESAME member countries to get hands-on experiences. A researcher on Structural Biology participated in an experiment at our PF facility for a month. Another researcher participated in element-analysis work at KEK and at Spring-8, learning basic techniques to analyze ancient relics. In addition, three leading researchers were invited and discussed with representatives of Japanese PF facilities (KEK-PF, Spring-8, Hi-SOR, UVSOR) that should be useful for future working together.

The other is a continuation of above-mentioned seminar. This year, the seminar will be held at Cairo University in Egypt. The representative of Egypt is Dr. Tarek Hussein, the President of Academy of Scientific Research and Technology of Egypt. Present Minister of Higher Education and Scientific Research, Dr. Hany Mahfouz Helal, was formerly the Director of management division of SESAME. In addition, this is the Egypt-Japan Science Year in Japan and Embassy of Japan will give us good help as well. Lectures will be given by 15 or so physicists from Japan as well as around 10 lecturers from SESAME member countries.

I hope we will be developing a good working relationships on science between Japan and Middle East.

The author of this article is ***Dr. Osamu Shimomura***, the Director of the Institute of Materials Structure Science.

OPEN SESAME!

SESAME stands for **S**ynchrotron light for **E**xperimental **S**cience and its **A**pplications in the **M**iddle **E**ast. It is a synchrotron facility which is being built in Jordan under the auspices of UNESCO. Currently, the full members of the project are Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey. Moreover, France, Germany, Greece, Italy, Japan, Kuwait, Portugal, the Russian Federation, Sweden, the United Arab Emirates, UK and USA will act as observers. Phase I beam lines are expected to become operational in 2011. **SESAME** offers an outstanding opportunity to promote science and technology in the Middle East as well as encourage mutual understanding, peace and cooperation.

I am a structural biologist by education and training. I use macromolecular X-ray crystallography as one main tool to answer interesting biological questions. I have been away from my home country (Egypt) for about 10 years seeking knowledge and experience in the field. Ten years ago, there was not a single structural biology laboratory in all of Egypt (and probably in the entire Arab world) and unfortunately the situation has not changed ever since. In an attempt to stir things up, I have been going back to Egypt more often to teach at Cairo University and help in organizing series of workshops and short-term schools.

This year, in November, the Japanese Society of Promotion of Science (JSPS) and KEK among other sponsors supported a one-week **SESAME** school at Cairo University Egypt (www.sesame.asrt.sci.eg) on Synchrotron related sciences. About 20 Japanese scientists flew to Egypt to give lectures and hands-on practical sessions to students and scientist coming from all **SESAME** countries. The success of the school was really astonishing.

I am now a faculty member in the Biophysics Department, Cairo University and concurrently work at the structural biology research center of the Photon factory with Prof. Soichi Wakatsuki. I am really grateful to the JSPS and Nishina foundation for providing me with a generous fund to develop several structural biology projects and also get training in synchrotron beam line commissioning and operation. Moreover, my family and I are enjoying the beauty of Tsukuba city along with the decency and generosity of the Japanese culture.

The author of this article, ***Dr. Mohammad Yousef*** is an assistant professor of Biophysics at Cairo University-Egypt and concurrently a JSPS-NISHINA fellow at PF. He is using synchrotron-based techniques to answer basic biological questions related to asymmetric cell division and also to re-engineer proteins for nano-biotechnological applications.

T2K Makes Rapid Progress

As the prime building block for the matter we see around us, the elusive particles known as neutrinos seem a pretty poor candidate. They interact only weakly with matter. They have almost no mass and are barely visible at all. However neutrinos may lie at the heart of the answer to one of the biggest problems facing physicists today: why does the Universe contain matter and not anti-matter? This question greatly puzzles physicists, because the known laws of physics would have converted the energy of the Big Bang into almost equal quantities of matter and anti-matter. We know from astronomical observations that in fact the Universe contains no significant amount of anti-matter, which leads to an exciting conclusion – there must be unknown laws of physics which governed the creation of all the matter we see around us.

Nothing will set physicists on the chase quicker than a demonstration that there are new laws of physics to discover. KEK's BELLE experiment has been searching for these new laws of physics, and the upcoming experiments at CERN could see many other new possibilities, but all these experiments are blind to one possible source of the excess matter – perhaps it came from neutrinos? This process, called leptogenesis, would have taken place in the very early Universe, however it may have left behind a hint in the properties of the neutrinos we observe today. This hint would appear in the new phenomenon of neutrinos demonstrated by the Super Kamiokande and KamLAND experiments – neutrino oscillations. These oscillations cause one type of neutrino to change into another, and the hint would be if these oscillations were different for neutrinos and anti-neutrinos.

In order to search for this effect we must first observe a new type of neutrino oscillation, not seen in previous experiments, whereby electron neutrinos will appear in a beam of muon neutrinos fired hundreds of kilometers underneath Japan. The muon neutrino beam will be produced at J-PARC by KEK physicists and their T2K colleagues from North America and Europe. Careful measurements of the composition and energy spectrum of the neutrino beam will be made before it leaves J-PARC using a set of "near detectors". The beam will then propagate underneath Japan to the Super Kamiokande experiment. Any differences between the properties of the neutrino beam seen in the near detectors and Super Kamiokande will be a signature of neutrino oscillations, with the longer-term goal being to compare the oscillations of neutrinos and anti-neutrinos to look for subtle hints to the physics behind leptogenesis.

In April next year, the first neutrino oscillation measurements of T2K will start. The near detectors which will analyse the neutrino beam

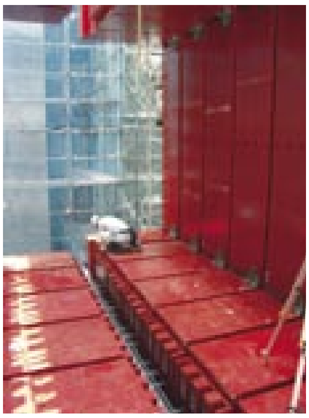


Figure 1: The iron yokes of the UA1/NOMAD magnet donated by CERN installed in the T2K near detector hall at J-PARC.

are being prepared in laboratories around the world. One detector, called INGRID, monitoring the direction and profile of the neutrino beam, is being built primarily by groups from Japan and France. A second detector will measure the spectrum and composition of the neutrino beam. One set of sub-detectors (called the tracker) consists of a fine-grained active neutrino target called the FGD (being built in Canada with critical contributions from Japanese groups) and a set of time-projection chambers (being built by Canadian and European groups), which precisely track particles created by neutrino interactions in the FGDs, allowing a precise measurement of the neutrino energy spectrum. Slightly nearer to the neutrino target is the P0D (being built in the US), a detector designed to measure neutral pions, which are a particularly troubling product of neutrino interactions because their decay can mimic the electron neutrinos we are searching for. These sub-detectors are surrounded by an electromagnetic calorimeter (being built in the UK), which will allow further studies of backgrounds which could mimic electron neutrino events. All of these sub-detectors will be contained within a huge magnet (originally used in the UA1 and NOMAD experiments at CERN, and then donated by CERN to T2K), which has now been refurbished and shipped from Geneva to Tokai and installed in the detector pit (see figure). The iron of the magnet is even a detector – scintillator sheets are being slipped into the gaps between the iron plates by groups from the US, Russian, Poland, and Japan to detect muons emitted from neutrino interactions which manage to punch through all the other sub-detectors.

Of course all this effort to make and understand the neutrino beam is only the first half of the problem. You have to detect the neutrinos after they have oscillated their way under Japan, and that requires a massive detector capable of untangling the electron neutrinos which have appeared from the remaining muon neutrinos and, even more importantly, the various background processes that could mimic electron neutrinos. That is the job of the 50,000 ton Super Kamiokande detector, which will try to add the first observation of electron neutrino appearance to its already stunning record of neutrino observations (including the first compelling evidence of neutrino mass from measurements of neutrinos coming from cosmic ray interactions in the atmosphere). Super Kamiokande has been rebuilt with new phototubes, and is currently having all its electronics and data acquisition system upgraded to make it even more capable and reliable for T2K's running period. The first neutrino measurements will begin in April 2009, hopefully opening a period of new discoveries of fundamental importance to our understanding of how the world came to be.

The author of this article, ***Dr. Dave Wark*** is a Professor of Physics at Imperial College London and the Rutherford Appleton Laboratory. He has been involved in neutrino physics for almost 30 years, and is currently International Co-Spokesman of the T2K experiment.

Obituary: Yoji Totsuka, Former Director General of KEK

Yoji Totsuka, the former director general of KEK and an outstanding contributor to great advances in neutrino physics, died of cancer at the age of 66 on Thursday, July 10, 2008.

Totsuka was one of the first-generation students to study under Professor Koshiba, the 2002 Nobel Prize Laureate in Physics, at the graduate school of the University of Tokyo. Upon receiving his Ph.D. degree in 1972, Totsuka began his career working on DASP, an electron-positron collider experiment in DESY, Hamburg, as a research associate of the University of Tokyo. Later, he joined in other experiments including JADE. In 1981, Totsuka was requested to come back to Japan by Koshiba, to build the Kamiokande, a large water Cerenkov detector. In 1988, he took over the role of Kamiokande spokesperson from Koshiba, and led the design and construction of Super-Kamiokande, which brought him and his colleagues to the discovery of atmospheric neutrino oscillations in 1998. In October 2002, he moved to KEK and worked as the Director General from 2003 to 2006. He was a professor emeritus of KEK and of the University of Tokyo. He received numerous awards: Asahi Prize (on Kamiokande,1988), Nishina Memorial Prize (1987), Bruno Rossi Prize (1989), Asahi Prize – (on Super-Kamiokande,1999), Purple Ribbon Medal (2001), Fujiwara Prize (2002), Panofsky Prize (2002), Culture Merit (2002), Order of Culture (2004), Bruno Pontecorvo Prize (2004) and Franklin Institute Awards (2007).

I worked with him at Kamiokande and Super-Kamiokande for more than 20 years. We started the design and construction of Kamiokande and then the upgrading to Kamiokande-II and -III. In the meantime, we had a very enjoyable time observing the neutrino bursts from SN1987A, confirming the solar neutrino problem and detecting the atmospheric neutrino anomaly. These physics outcomes blew off the tight and heavy workload during the Kamiokande upgrade. In parallel to such Kamiokande activities, he led the design and development of the Super-Kamiokande detector. We had many discussions and sometimes quarrels. His very straightforward nature always gave us a friendly atmosphere and encouragement. I remember one winter night at Kamioka in around 1990, where we were drinking sake. We had an urgent phone call from the university (originated from the government) which asked us to come up with 10 items that would demonstrate the usefulness of Super-Kamiokande for human life within one hour. This type of question from the government implies that the budget approval (for Super-Kamiokande) is coming up. Thanks to sake, we could come up with eccentric ideas to answer for the inquiry. Whilethe Kamiokande was growing into a big enterprise, Super-Kamiokande, , he exercised excellent leadership, and led to the discovery of atmospheric neutrino oscillations. He was a prominent leader both in non-accelerator and accelerator neutrino experiments. He established the financial and international organization structure for K2K and T2K, accelerator based long baseline neutrino oscillation experiments. He was also very proactive in pushing foward international cooperations with members of many large particle laboratories. He was one of the most outstanding physicists.

Atsuto SUZUKI, Director General

Koh, the sophisticated fragrance of Japan

Koh Wood

It all started in the 6th century when pieces of fragrant wood reached Japan.

When it was burnt, it emitted a heavenly fragrance and astonished people. Since then, Japanese have been obsessed by the smell.

Humans are quite sensitive to light and sound but not as much to other sensation such as smell. Light and sound reach you very fast so that they are very important for humans to make quick decisions.

Humans failed to retain full smelling capability they presumably had many thousands of years ago. It's a pity that the sense of smell is given the lower priority. Without a smell, we would not fully enjoy a good meal and wine and, well whatsoever. Should we call this a sign of advancement?

While the perfume business is going strong, but it is only for a single purpose of attracting someone. (Fortunately, that part of human instinct is still going strong.)

Koh is quite different from perfumes. It's neither an aphrodisiac nor like the smoke from burning some kind of plants. The smell of a good quality Koh is an experience one can really appreciate in the midst of busy everyday life. It soothes and heightens human spirit.

These fragrant woods were mysteriously created by chance and are found only in some region of south-east Asia. None have been found in Japan despite of efforts to find them. So, it is surprising that Japanese have developed sophisticated way to appreciate Koh.

Mr. Masataka Hata (picture left) is the president of one of the highly regarded Koh manufacturers in Kyoto. His family started the Koh business in 1705 and he is the 12th-generation head of the family. He has been leading the quest for the great Koh materials throughout the world. It is not unlike the case of someone trying to make a small lake in the middle of a desert to please people. It would require a tremendous effort to get it going. It should also be noted that no two Koh woods produce the same aroma. Hence it requires extremely sophisticated sense of smell to blend Koh materials for a specific aroma. It is an art by itself.

Through the long history, the way of Koh became more sophisticated. To start with, they consider the word "smell" too naïve. Instead, they use the phrase "Listen to Koh".

Various games have been developed. For an example, you are to "listen to" 5 randomly sampled, heated tiny Koh wood chips (approx. 2mm size) and to identify which ones are cut from the same wood and which ones are not (see picture). There are 52 possibilities, including "all of them are different" and "all of them are from the same piece of wood". Neat thing is that you should use the name of a chapter in the novel "The Story of Genji" written around 1001AD. The novel has 54 chapters each of which has its chapter name. (Two of them are not used, obviously.)

For example, if you found that "the first two are the same and the others are all different", you write down your answer as "Aoi" (the 9th chapter). I attended one of such games recently and realized how difficult it is to detect subtle aroma differences. It was also fun and I would love to try it again.

When you come to Japan, try a good quality Koh and experience the great sensation as ancient Japanese had experienced some 1400 years ago. Some comes in stick form, some comes as a small wood chip, and so forth. Sticks come with varieties of aroma. It is a mixture of various fragrant materials. You may find the one you get attached to.

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Editor : Tokio K. OHSKA, e-mail: tokio.ohska@kek.jp
Please send comments to : KEK International Affairs Division
1-1 Oho, Tsukuba, Ibaraki, 305-0801 Japan
telephone +81-29-864-5130, telefax +81-29-864-5195
e-mail tminami@mail.kek.jp