「加速器」Vol. 6, No. 1, 2009 (6–9)

寄　稿

The KEKB Machine Advisory Committee

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1. Introduction

On December 10, 2008, in Stockholm, Yoichiro Nambu, together with Makoto Kobayashi and Toshihide Masukawa, were awarded the Nobel Prize in Physics–Nambu ''for the discovery of the mechanism of spontaneous broken symmetry in subatomic physics'', Kobayashi and Masukawa ''for the discovery of the origin of the broken symmetry which predicts the existence of at least three families of quarks in nature.'' In the Presentation Speech, Professor Lars Brink, Member of the Royal Swedish Academy of Sciences and Member of the Nobel Committee for Physics, declared: ''During the past decade, elementary particle physicists have measured Kobayashi and Masukawa's theory with great precision and found that it really does fit the data.'' The Nobel Foundation elaborated: ''It is only in recent years that scientists have come to fully confirm the explanations that Kobayashi and Masukawa made in 1972. They explained broken symmetry within the framework of the Standard Model, but required that the Model be extended to three families of quarks. These predicted, hypothetical new quarks have recently appeared in physics experiments. As late as 2001, the two particle detectors BaBar at Stanford, USA and Belle at Tsukuba, Japan, both detected broken symmetries independently of each other. The results were exactly as Kobayashi and Masukawa had predicted almost three decades earlier.''

It was because of these confirming measurements that Katsunobu Oide, head of the KEKB Group, and Fumihiko Takasaki, the first head of the BELLE Detector Group, were invited to Stockholm to attend the presentation ceremony. Jonathan Dorfan and Dave Hitlin, representing the PEP–II B-Factory at SLAC, were also invited. The presence of these scientists at that event underscores the importance of the research carried out at the B-factories. It also underscores why participation on the KEKB international Machine Advisory Committee has been such an extraordinary professional and educational experience for those of us who have been privileged to serve.

2. The Beginning

Shin-ichi Kurokawa, the KEKB Project Leader, is well known for his international outlook, for his scientific humanitarianism, for his involvement in SESAME, and for his scientific travels. This statesman of science had long believed that a scientific enterprise of this scope and importance would need an advisory Committee that was international, and Director General Hirotaka Sugawara agreed. Thanks to Kurokawa-san and the Director General, that first meeting in 1995 enabled the authorities in Japan to see how such a Committee would work.

The earliest incarnation of the Committee first met in June 1995, chaired by the late Gustav-Adolph Voss of DESY, whose work had included leading the construction of PETRA, PIA, and the electron ring for HERA. Besides Chairman Voss and myself, the other original Committee members were Alex Chao of SLAC, Dave Gurd of LANL, Susumu Kamada of KEK, Hasan Padamsee of Cornell, Flemming Pedersen and Wolfgang Schnell of CERN, John Seeman of PEP–II at SLAC, Dieter Trines and Anton Piwinski of DESY, and, as Committee Secretaries, Shin-ichi Kurokawa and Fumihiko Takasaki.

The executive summary that first year began, ''B-factories belong to a new generation of e^+e^- colliders that exceed in many aspects known performance data of existing electron positron colliding machines by

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large factors and present a real technical challenge. The desired luminosity of 10^{34} cm^{-2}s^{-1} in B-factories is by a factor of 50 higher than that of the highest luminosity in presently existing e^+e^- storage rings.'' It went on to outline the challenges and to propose that the ''KEKB design approaches these challenges in a bold and highly original way.'' The Committee also offered what it called ''cautionary words,'' but concluded by expressing confidence ''that the design objectives can be met.''

After a hiatus of a year and a half, it was decided that the international Machine Advisory Committee (MAC), would meet annually in February or March, with the ensuing reports to be used in KEK's annual performance reviews. To make the Committee even more international, two Asian members were added: Won Namkung of Postech, Korea, and Wang Shuhong of IHEP, China, both of whom are still actively involved. This then was the Committee that oversaw the construction project, which lasted until 2000.

3. KEKB Construction

As in all such large, cutting edge projects, there were many difficult decisions to be made and the Committee evaluated the suggestions of the KEKB experts and provided advice. We watched as TRISTAN was cleared out of the tunnel and the new components arrived, were measured and installed. Finally, the great day arrived and commissioning of KEKB started on Dec. 1, 1999. The first electron beam was stored in the 8 GeV high energy ring only twelve days later, and on Jan. 10, 2000 positrons were injected into the 3.5 GeV low energy ring and subsequently stored. By the middle of April 2000, 524 mA of e^- and 514 mA e^+ were accumulated and stored in the two KEKB rings. At the beginning of May 2000 the BELLE detector was moved into place, and one month later the first hadronic events were produced in e^+e^- collisions and observed in BELLE. This rapid start-up showed how well the KEKB team had done their job and gave an indication of the future performance.

4. Commissioning and Operation

At that time, most machine advisory Committees closed down when commissioning began because funding agencies no longer required them. But to the credit of Kurokawa-san and the successive Directors General, the KEKB MAC has continued, not only during commissioning, but into the period of operation and improvements.

Fig. 1 Katsunobu Oide in the control room with Haruyo Koiso

The sixth KEKB Accelerator Review Committee in 2001 was the first meeting without Dr. Gustav Voss, who had been the Chairman of all previous meetings. I took over as Chairman, and the Committee membership was partially modified to be able to focus on the issues of a running machine. It also coincided with the promotion of Katsunobu Oide to become the head of KEKB Operations (**Fig. 1**). It has been Oide-san who has provided the inspiration and leadership for making KEKB a world leading accelerator.

It's interesting to recall how encouraging the Committee was able to be in the 2002 report (**Fig. 2**). The Committee wrote, ''KEKB has made spectacular progress over the last year, breaking almost all of the previous worldwide luminosity records: highest peak luminosity: 6.6×10^{33} cm^{-2}s^{-1}, highest daily integrated luminosity: 329.5 pb^{-1}, highest 7 day integrated luminosity: 2.06 fb^{-1}, and highest 30 day luminosity: 7.56 fb^{-1}.''

Similar encouraging progress was highlighted in all of the Committee reports from 2003 to 2006 as the luminosity reached the design value of 10^{34} cm^{-2}s^{-1} in May 2003, the first electron collider to reach this milestone. The collider set the current world luminosity record of 1.71×10^{34} cm^{-2}s^{-1} in November 2006.

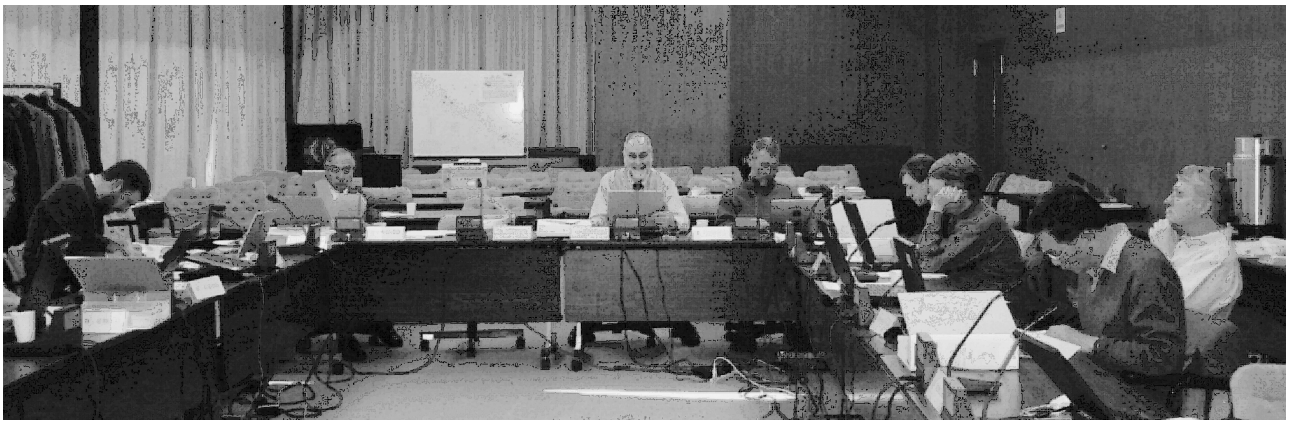

Fig. 2 The KEKB Machine Advisory Committee at work

Fig. 3 Kenji Hosoyama, leader of the crab cavity construction with Committee members

Fig. 4 Committee members observing machine studies in the control room

5. Crab Cavities

In 2006, following more than a decade of development, two superconducting crab cavities were installed to increase the luminosity even further based on detailed simulations that predicted a small area of tune space where the luminosity would be enhanced. The construction of the crab cavities was extremely difficult and required the combined skills of the KEKB staff and even some useful advice from the Committee members for the final assembly (**Fig. 3**).

By November 2007, the KEKB experts had managed to tune up the luminosity to 1.47×10^{34} cm^{-2} s^{-1}, obtained with smaller beam currents, but had not managed to exceed the previous luminosity record. It was believed that the tuning algorithms were not able to converge on the correct settings, so the Committee was invited to a new type of meeting, to be held in the control room. As the machine was brought up from an extended downtime, the KEKB experts explained each step that was to be carried out, and then invited the Committee to observe as the procedure was carried out, inviting suggestions for improvement (**Fig. 4**). This showed a rare display of confidence in the Committee: most of us involved in accelerators would not have the courage to allow ''outsiders'' to see our problems in real time.

Following several days in the control room, the Committee exited, vanquished. We had made many suggestions, several of which were enacted immediately, without being able to improve on the optimization procedures already developed by the KEKB experts.

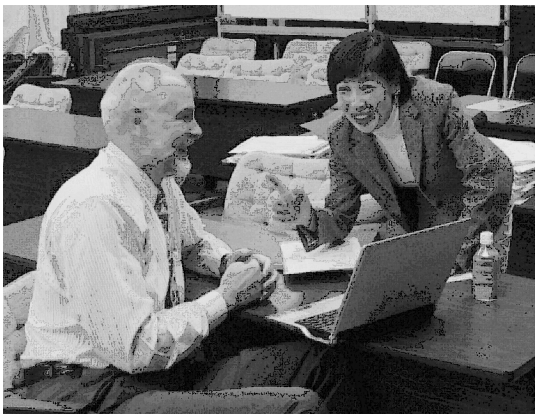

Fig. 5 Yoko Hayashi and Andrew Hutton in discussion

6. The Future

Preparations are now underway for the next phase, developing plans for SuperKEKB with an initial luminosity goal ten times that of KEKB. The Committee is convinced that the KEKB accelerator experts will approach this next adventure with as much boldness and originality as they did for KEKB.

7. Acknowledgements

For those of us who have served for so long, this Committee has been an extraordinary experience. We gained far more than we could give. This discussion would not be complete without mentioning our wonderful organizer, Yoko Hayashi, who has been providing organizational support since the very beginning (**Fig. 5**). In fact, many of us cannot imagine coming to KEK without Hayashi-san to look after our needs.

Appendix

Members of the KEKB Machine Advisory Committee 1995–2009 (in alphabetical order):
Yunhai Cai (SLAC) [2006]
Alexander W. Chao (SLAC) [1995–2009]
Dave Cinabro (Wayne Univ.) [1997, 1998]
Nikolay Dikansky (BINP) [1997–2000]
Warren Funk (JLab) [2003–2009]
Oswald Gröbner (CERN) [2004–2009]
Dave Gurd (LANL) [1995–2000]
Heino Henke (Technische Univ. Berlin) [2005–2007]
Georg Hoffstaeter (DESY) [2001–2006]
Stephen D. Holmes (FNAL) [2001]
Andrew Hutton (JLab) [1995–2009]
Susumu Kamada (KEK) [1995,1997]
Peter Kneisel (JLab) [2002]
Masanori Kobayashi (KEK) [1998–2002, 2004]
Shin-ichi Kurokawa [1995–1999, 2003, 2006–2008]
Trevor Linnecar (CERN) [2005– 2009]
Won Namkung (Postech) [1999–2009]
Katsunobu Oide (KEK) [2006–2009]
Hasan Padamsee (Cornell Univ.) [1995–2000,]
Fleming Pedersen (CERN) [1995–2009]
Eugene A. Perevedentsev (BINP) [2001–2009]
Anton Piwinski (DESY) [1995]
David Rice (Cornell Univ.) [2001–2009]
Wolfgang Schnell (CERN) [1995–2003]
John T. Seeman (SLAC) [1995–2009]
Wang Shuhong (IHEP) [1997–2009]
Ronald Sundelin (JLab) [1999–2001]
Fumihiko Takasaki (KEK) [1998, 1999, 2003]
Dieter Trines (DESY) [1995–2000]
Gustav-Adolf Voss (DESY) [1995–2000]
Masanori Yamauchi (KEK) [2009]