The Ninth KEKB Accelerator Review Committee Report

Introduction

The Ninth KEKB Accelerator Review Committee meeting was held on February 16-18, 2004. The Committee welcomed one new member: Oswald Gröbner from CERN, one of the world's experts on accelerator vacuum systems. Two other members have been appointed and will attend the meeting next year: Trevor Linnecar from CERN and Heino Henke from Berlin University, both experts on accelerator RF systems. Appendix A shows the present membership of the Committee.

The ninth Committee meeting followed the usual format of oral presentations by the KEKB staff members and discussion by the Committee members. The Agenda for the meeting is shown in Appendix B. As usual, the Committee was impressed by the high standard of the talks, both the technical content and the presentations themselves. The recommendations of the Committee were presented to the KEKB staff members before the close of the meeting. The Committee wrote a draft report during the meeting that was then improved and finalized by e-mail among the Committee members.

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A) Executive Summary

1) Foreword

KEKB has made excellent progress in the year since the last Committee meeting. The peak luminosity has increased to a new world record of 11.6 x 10^{33} $cm^{-2}s^{-1}$ (at this time last year it was 8.26 x 10^{33} $cm^{-2}s^{-1}$, the year before 6.65 x 10^{33} $cm^{-2}s^{-1}$). KEKB exceeded the design luminosity of 10^{34} $cm^{-2}s^{-1}$ on May 9, 2003. The Committee congratulates the entire KEKB project staff on achieving this major milestone. Continuous injection has been in regular operation since January 2004, and has helped to increase the daily integrated luminosity by almost a factor of two since last year. The BELLE detector has accumulated 197.5 fb^{-1}, another world record (107.4 fb^{-1} last year and 56 fb^{-1} the year before) and has published a total of 83 papers in refereed journals (55 last year). In the two-day meeting, only a few of the talks dealt with present status of KEKB, while the remainder covered the plans for upgrading KEKB to a luminosity of 10^{35} – 10^{36} $cm^{-2}s^{-1}$. The KEKB machine group had done an enormous amount of excellent work, and is to be congratulated on the impressive results that have been achieved.

2) Summary

KEKB has made spectacular progress over the last year, breaking all of the worldwide luminosity records: highest peak luminosity: 11.6 x 10^{33} $cm^{-2}s^{-1}$, highest daily integrated luminosity: 819 pb^{-1}, highest weekly integrated luminosity: 4.745 fb^{-1}, and highest 30-day luminosity: 17.24 fb^{-1}. The machine is running exceptionally well (the daily record was exceeded during the meeting) and it is expected that the luminosity will continue to slowly increase during the year. However, no large factors of improvement seem likely until the crab cavities can be installed. The KEKB team has made many hardware and tuning improvements in order to reach this performance and they are to be congratulated on the excellent results.

The BELLE detector has now accumulated 197.5 fb^{-1}, and of these 90 fb^{-1} were obtained this year. The BELLE detector is working extremely well and has had no major difficulties. Backgrounds are low, and losses during beam injection are small. Continuous injection has been acceptable to the detector but has necessitated suppressing 3.5 ms of data taking during each injection cycle. Overall, the BELLE collaboration is extremely pleased with the quality and quantity of the beam being provided by the accelerator.

3) Comments

The Committee has made recommendations throughout the different sections below. Highlights of these recommendations are summarized here for convenience.

1. The Committee believes that improving the luminosity of KEKB is the highest priority, and experimental and theoretical studies to improve luminosity should be given precedence.
2. The Committee strongly endorses the proposal to construct, test, and install a crab cavity in one ring with the highest priority, and recommends that a second cavity be installed in the other ring as soon as possible. In the meantime, detailed theoretical studies of the beam dynamics of the ring with a single crab cavity should continue.
3. Recognizing the criticality of the prediction of a high beam-beam parameter, the Committee strongly recommends an even more in-depth examination of these simulations. This is an exciting possibility, which has large potential for improving the luminosity of KEKB and also SuperKEKB.
4. The Committee would like to encourage studies leading to increased luminosity in the short term; e.g. electron cloud clearing in the quadrupoles, study of 3.5 bunch spacing, fast ion instabilities, reducing beta*, working point, shortening the abort gap, etc.
5. The Committee recommends that BELLE implement an azimuthally localized veto similar to that of BaBar to avoid the 3% loss in luminosity caused by the detector trigger veto during injection.
6. The Committee endorses the direction of the present studies to design a major luminosity upgrade (SuperKEKB) aimed at a luminosity of 10^{35} – 10^{36} $cm^{-2}s^{-1}$ and recommends that they be continued.
7. The Committee would like to see an integrated schedule for SuperKEKB, consistent with the external constraints, that can be used as the basis for defining the internal priorities for research and development, and can help focus detailed budget and scheduling work.
8. The Committee recommends carrying out a detailed evaluation of all of the effects that would impact the choice of which beam goes in which ring.
9. The Committee recommends installing one or more test chambers in the ring to study the effect of clearing electrodes, coatings, etc.
10. The Committee recommends that design studies of the ultimate damping rates of the transverse damping systems be continued in view of the importance of the fast ion instability.
11. The Committee recommends continued participation in the collaboration with SLAC to develop a new digital signal processing system for the multi-bunch feedback system and endorses the proposal to initiate a new collaboration with SLAC, BNL and other laboratories on electron cloud instabilities.

B) Findings and Recommendations

1) KEKB status

KEKB has progressed very well over the past year and more than reached its goals. The luminosity has reached 11.6 x 10^{33} cm^{-2} s^{-1}, a new world's record that exceeds the design value. The accelerator continues to set integrated luminosity records, for example, 819 /pb per day and 17.24 /fb in 30 days. The total integrated luminosity over the life of KEKB has reached 197 /fb.

On the technical front, injection of both beams while the detector is taking data was successfully achieved early last month. This continuous injection mode greatly increases the average luminosity. Also, the horizontal tune of the Low Energy Ring (LER) was recently moved closer to the half integer tune (0.505) which, with the use of IP tuning knobs, gives higher luminosity. Feedback on the bunch tunes has also greatly stabilized colliding beam operation.

KEKB now operates with about 1,200 bunches but with beam currents near the design values. This high bunch charge is well tolerated by the beam-beam interaction and, as a result, gives more luminosity. The design number of bunch (5,000) would allow for more current and luminosity in the future. However, the number of bunches is presently limited in the LER by the Electron Cloud Instability (ECI). The KEKB staff is looking at measures to increase the current and specific luminosity.

The high bunch currents and short bunch lengths have stressed several vacuum chambers with high temperatures and forces. Several vacuum leaks have occurred, and these chambers have been replaced and upgraded. The committee suggests continued vigilance watching for the "next" chamber to have problems.

The number of beam aborts has averaged about four per day in each ring since May 2002. Since continuous injection has been implemented, the beam aborts have had a noticeable impact on the average luminosity (~5%). The causes have been carefully documented and assigned to different categories. It would be interesting to study these beam aborts in more detail to try and eliminate them. This would be good for the present KEKB and, more importantly, provide useful information for SuperKEKB.

2) Experience on High Current

The committee was very pleased to learn that beam currents of 1.5 A and 1.1 A have been reached, record currents for a superconducting cavity system. The machine is operated with 1284 bunches which implies much higher bunch currents than the design value, because the electron cloud instability is the limiting effect for increased luminosity. A large HOM power is deposited in vacuum system components as a consequence of the high bunch currents.

Major problems that were encountered during the last year were excessive heating of the bellows near movable masks, heating of NEG elements, and increased outgassing of a getter cartridge in a pumping port. In several cases the excessive heating or arcing resulted in vacuum leaks that had to be repaired. To avoid such problems in the future, the cooling capacity of the critical elements has been increased. On one occasion, thermal deformation of a vacuum chamber provoked displacement of a magnet resulting in a loss of luminosity. It would be desirable to monitor closely the temperature of all critical components in order to avoid vacuum incidents and to anticipate problems,

Following the opening of the vacuum system during a shutdown, a series of sudden beam losses has been observed in the electron ring, which was attributed to dust particles. Fortunately, these incidents have the tendency to disappear after a relatively short period of operation. The Committee recommends monitoring such events as they represent a non-negligible loss of the integrated luminosity.

Following the successful implementation of continuous injection into KEKB, the beams can be maintained at a stable currents throughout the run and this has considerably improved the thermal conditions of the vacuum system, thus reducing movement of vacuum components and undesirable thermal cycles.

The electron cloud situation has improved considerably since the addition of solenoids wherever the beam pipe is accessible. The Committee recommends continued exploration of this approach, and to add solenoids to any remaining field free space. The question of the optimum field orientation of adjacent solenoids windings has been raised and whether or not this matters at all. The Committee recommends that this be studied theoretically.

The available data on vacuum scrubbing of the two rings shows a reduction in outgassing by many orders of magnitude and appear to have reached around a few 10-7 molecules/ photon. In the HER the clean up appears to be levelling off at a few 10-7 molecules/ photon. The reason for the saturation in the HER is not entirely understood but a plausible explanation could be increased thermal outgassing of the vacuum system due to chamber heating. As long as the achieved pressures are sufficiently low, this effect should not limit the operation at higher current.

3) Physics of BELLE, today and tomorrow

Belle has logged world records in peak luminosity, daily, monthly and totally accumulated luminosity of 197fb^{-1}, which gives the prospect of collecting 500fb^{-1} by 2007. What could be measured with luminosities from 5000 to 50000fb^{-1} is now being studied. Since the higher number is somewhat optimistic, it would be wise to avoid raising expectations too high. The Belle detector has been working very well. There are no major difficulties and the backgrounds are low. The new silicon vertex chamber has been working well with no reported problems.

Continuous injection has been implemented and works very well. The detector currently vetoes 3.5ms after every injection, which amounts to a 3% loss in luminosity. To avoid this loss, an azimuthally localized veto similar to that of BaBar should be implemented. Additional loss of luminosity is due to beam aborts. With the top up mode, a beam abort always happens at maximum current and therefore leads to significant loss in luminosity. A detailed abort analysis is encouraged, associated with an effort to reduce the number of aborts.

Belle has already been a very productive experiment. Currently 90 publications have been written. So far, the main mission of Belle was a test of CP-violation in the Standard Model by the Kobayashi-Maskawa mechanism. All three angles in the unitarity triangle have been measured. Furthermore, several searches for new physics have been published, for example via penguin diagrams. A new narrow resonance in B decays has been found that does not seem to be a charmonium state and more data is needed to understand the associated particle. Hints at a new CP violating phase in b to s coupling have been found. If this can be confirmed with more data, luminosity upgrades would lead to a very successful future of the B-factories.

4) Upgrade plan overview

The upgrade plan for SuperKEKB has been summarized in a Letter of Intent to be submitted to the KEK LCPAC in February 2004. A draft of the LOI was given to this Committee. The design target for the luminosity of SuperKEKB is 2.5 to 5 x 10^{35} cm^{-2} s^{-1}. There is a sound design strategy that 1) reuses as much of KEKB as possible, 2) maintains acceptable detector backgrounds, 3) has a new powerful injector, 4) has a low beta function interaction region with a crossing angle, and 5) has high beam currents. Many accelerator advances are required for SuperKEKB to carry out this approach. These include new superconducting magnets in the interaction region, an upgraded linac to provide high-energy low-emittance positrons for injection, a flexible arc lattice, an enhanced RF system for high currents, a new high power vacuum system and improved beam diagnostics.

The Letter of Intent calls for a ten-year construction project starting as early as FY2004 and continuing until FY2013. The strategy calls for building most of the components for SuperKEKB in the first few years while continuing to operate the present rings. Then, there would be a one to two year down to install the components around FY2007. The new SuperKEKB accelerator would turn on in the fifth year of the proposed plan. Additional upgraded components would be installed over the following five years during the summer downs while the accelerator is off.

A large factor in increasing the luminosity comes from an increase in the assumed beam-beam interaction. Computer simulations have shown a factor of two-to-four increase in the beam-beam parameter at high tune shifts due to the use of crab-cavities. These cavities reduce the effects of the required large crossing angles at the interaction point making them look similar to head-on-collisions. These simulations use macro-particle tracking codes with transverse and longitudinal motion of the particles. The KEKB staff is aware that the highest values of the tune-shift are obtained from gaussian model simulations that might not be realistic. The Committee recommends that additional simulations be continued to make absolutely sure that this anticipated luminosity gain is realizable and to understand the errors that could reduce this factor. Possible reductions may come from non-linearities in the arc lattice (e.g. chromaticity, sextupole errors, etc), longitudinal effects (number of simulation slices), or any interaction region error (coupling, dispersion, etc).

The upgraded KEKB will have bunch lengths of about 3 mm. The Committee suggests continued studies of bunch length effects including coherent synchrotron radiation (CSR), enhanced Higher Order Modes (HOM), and bunch lengthening.

Overall, the plan for SuperKEKB is well thought out and many successful prototype tests have been completed. The Committee recognized the hard work that has been done for the design. The Committee believes that a better definition the possible funding timetable would help in making decisions on the relative priority of the research and development program.

5) Beam-beam interaction

Extensive efforts were invested in the development of a 3-D simulation code for the beam-beam interaction. This code has been benchmarked against the present operation of the KEKB. An effort has also been made to compare it with another code independently developed at SLAC, which has been benchmarked against PEP-II operation and in general, good agreement has been obtained between the simulations and the real machines. This simulation code is now being used to extrapolate to SuperKEKB. It predicts a substantial increase of the beam-beam parameter (from the present KEKB level of 0.05 to the predicted level of 0.14) when the beams collide either head-on, or with crab crossing. The SLAC code also makes the same prediction. This result offers an exciting path to higher luminosities, and in fact lays the foundation for a predicted luminosity for SuperKEKB of 2.5×10^{35} cm^{-2} s^{-1}.

Recognizing the criticality of the prediction of a high beam-beam parameter, the Committee strongly recommends an even more in-depth examination of these simulations. In particular, linear and nonlinear optics errors in the ring lattice should be included in the simulations. Attention should be paid to possibility of beam-beam induced synchro-betatron resonances. The Committee feels that the criticality of the issue justifies continued scrutiny.

Another intriguing observation made in this study is to suggest that quantum excitation plays an important role in blowing up the vertical beam size so that the blowup is extremely sensitive to the crossing angle and the x-y coupling. Since the prediction of the increased beam-beam parameter is related to this observation, it is suggested that this observation be benchmarked against other simulation codes and/or other colliders.

It is suggested that emphasis be concentrated on a strong-strong simulation using the PIC technique. The weak-strong and/or the Gaussian model simulations, which have been carried along in the studies, do not reflect the KEKB reality but may be useful in special situations.

6) Crab cavities: Status & Plan

It is a pleasure to see the significant progress made on the crab cavity development, as well as planning for testing and installation. The crab cavities are the core component of both the KEKB luminosity upgrade and the future SuperKEKB. The Committee strongly believes that the design, construction, and testing of these cavities should be given the highest priority, as this is one of the few proposals that could lead to a significant enhancement in the KEKB luminosity in the years before SuperKEKB goes online.

The fast processing of the cavities and the maintenance of a low breakdown rate is very encouraging. The cryostat design is advancing well and it will be important to maintain this progress to meet the scheduled test date in mid-2004. The beam test in 2005 will be a milestone in accelerator physics.

Several areas of the crab cavity system are covered in more detail below.

7) Crab cavities: Cryostat R&D

It is gratifying to see that work has started on the design and construction of the crab cavity cryostat. Given the importance of this device to future luminosity improvements it is greatly hoped that resources will be available to aggressively pursue completion and early testing.

Considerable work has gone into calculating heat leaks, which look reasonable. If possible, additional heating due to beam-driven trapped modes should be ruled out, since it could lead to the need to modify the design of the helium vessel or cryostat.

The cavity is only supported from the top, raising the possibility of motion during cool down. If not done already, we suggest a complete analysis of the mechanical aspects during cavity cool down.

The mechanism proposed for tuning the cavity appears mechanically reasonable, but the design details presented do not make it immediately obvious that the necessary degree of pitch and yaw control can be achieved.

8) Crab cavities: Nb-Cu coaxial coupler R&D

The presentation on the RF design of the input coupler showed that considerable thought has gone into this effort, with the result that there seem to be several design choices that can be made to work. One issue that was not addressed in the presentation to the Committee was the thermal design of the outer conductor, which is tied to 4.5K at the beam pipe, 80K somewhere along its length, and 300K at the cryostat wall. Relative thermal contraction of the inner and outer conductors will modify Q_{ext}, making strong reflections, large VSWR and outer conductor heating likely.

Equal care has gone into the RF design of the coaxial coupler where the effects of differential thermal contraction will be even more significant, since the operation of the coupler depends on the existence of relatively high-Q resonances. Thermal effects will shift these resonances, so the effects of cool-down will have to be considered in the engineering design. The coupler penetrates into the high RF magnetic fields in the center of the cavity, resulting in excitation of substantial eddy currents. Clearly, the surface resistivity will have to be low enough, and the thermal conductivity back to the helium bath high enough, such that the current-carrying surfaces remain superconducting. It would be prudent to use bulk niobium for this coupler. It is not clear that a sufficiently high quality niobium film can be created for this purpose without significant effort, and that effort might be better applied to solving other problems of the cryostat. Analysis of heat transfer in the coupler will determine the allowable losses due to eddy current heating of the coupler tip.

9) Crab crossing optics

The Committee encouraged expediting the crab-collision test at KEKB in the previous Review. The economic option is to use one crab cavity per ring, which is also potentially an important test prior to producing the full set of 2×2 needed for compensated crab kicks in both LER and HER.

Since the last review, the KEK staff has developed optics schemes that meet the basic requirements of the single crab cavity installation. The previous HER lattice has been modified to reduce the cost of ring components, and the LER lattice is a new design.

The proposed changes are generally reasonable and address most of the needs of the crab cavity compensation. The crab compensation is potentially a major factor in the performance of KEKB, as well as in future machines. Demonstration of the effectiveness of crab compensation will be a major step forward in colliding beam accelerators. The importance of crab compensation merits a detailed examination of all the potential effects on machine performance.

The horizontal position of the beam in the crab cavity must be controlled to approximately ±1 mm to avoid loss of control of the crabbing mode field due to beam loading. (The exact limit is dependent on the choice of the cavity RF coupling coefficient.) In the HER with $\beta_X = 200$ m this corresponds to 0.5 beam sigma. A reliable feedback system will be needed to minimize beam aborts from exceeding this limit.

The single-particle dynamics analysis was performed with the crab-cavity by the 6D linear optics code used at KEK (SAD). It includes the coupling of x- and z-emittance, beam sizes of the coupled beam, and excitation of the first-order synchro-betatron resonances. The latter are of importance with regards to the preferred working point between the half integer and the 1st sideband. The realization of effective compensation of the crossing angle was implicit in the presentations. However, details, including the 6x6 (or even 4x4) coupled one turn matrix at the interaction point were not presented. Similarly, it was not clear that the dispersion in the crab cavities has to be zero. While this may not be a major issue in KEKB, if it is intended to use a single crab cavity in SuperKEKB, zero dispersion would leave no opportunity to control beam emittance with wigglers since the wigglers in Oho will have to be removed for installation of the RF cavity.

The dynamic aperture simulation demonstrates acceptable values and is maintained until the limits of the detuning of the betatron phase advance between the Crab cavity and the IP from the lambda/4 condition are approached.

Collective effects, including the static current-dependent head-tail tilt of a bunch as the bunch is crabbing around the ring circumference, should be the subject of further studies. The Committee recommends simulation of the single-bunch electron-cloud instability with crabbing bunches.

Finally, we note that the mask phase to the IP for the D09H1~D09H4 mask is changed by 108 degrees. No implications of the change were presented.

10) Crab cavities for high currents

Those considering the problem of a crab cavity for the high currents of SuperKEKB have produced an excellent RF design, and have correctly identified the removal of HOM power as a critical concern. They have accordingly proposed the installation of three different types of HOM couplers: waveguide couplers sited at the points of maximum electric field in the crabbing mode, coaxial couplers along the line of symmetry between those points, and beam pipe absorbers.

The designers plan to dissipate the HOM power at 300K, which should be fairly straightforward for the coaxial coupler and the beam pipe absorbers, but could be difficult for the crossed waveguides. Consideration of the engineering design should be an early priority.

Although the coaxial coupler will not couple crab mode power out to the load if it is accurately located along the line of symmetry, it will nonetheless be supporting large crab mode eddy currents, with the possibility of significant heating due to its exposure to the RF magnetic field. The thermal design of this coupler should therefore be a priority activity, particularly for the normal conducting version of the crab cavity.

For SuperKEKB the crossing angle is increased from 22mrad to 30mrad. The required strength of the crab cavities is not increased however since an appropriate increase of the beta function at the crab cavities is planned. While this measure reduces the required kick strength, it limits the tolerable transverse impedances to smaller values. Furthermore, larger beta functions reduce the tolerable closed orbit amplitudes and an orbit feedback becomes necessary.

The high current crab cavity design presented is rather new and no construction plans have been developed, yet. Since the SuperKEKB luminosity prediction relies on the success of the crab cavity concept, the Committee recommends early planning for the production of high current crab cavities.

The abort gaps cause a shift of the synchronous RF phase that increases with the distance between the bunch and the abort gap. This leads to different closed orbits for different bunches in both rings. While the shifts in the two rings lead to displacements at the IP that are in the same direction, their amplitude is not the same and a beam offset of ±14 micron in the horizontal plane has been computed. Considering the sensitivity to transverse displacements at the IP that has been observed at PEP-II, we recommend fighting this effect by controlling the RF phase shift with a feed forward system.

11) RF system upgrade

The existing ARES and SCC RF systems are presently operating with remarkable reliability and appear to be very well engineered for the present currents. For the planned SuperKEKB upgrade a current increase to 9.1 A in the LER and 4.1 A in the HER is required. An upgrade plan was presented that re-uses as much as possible of the present RF hardware. This creates several major challenges in the ARES and SCC RF system:

a) Fast growth of the ARES fundamental RF driven longitudinal -1 mode, $\tau = 0.3$ ms
b) Longitudinal coupled bunch instability driven by the RF cavity HOMs which exceeds the radiation damping: $\tau = 5$ ms in LER
c) Fast longitudinal coupled bunch instabilities driven by unbalance of the ARES cavity impedance of 0 and π modes: $\tau = 3 – 4$ ms
d) Much larger HOM power per cavity for both ARES and SCC cavities: factors of 3 to 7 times higher.
e) Required beam power increased by about a factor 4: 18.4 MW (LER) and 16.0 MW (HER).
f) Increased beam gap transients due to the increased currents.

The proposed plan and R&D programs underway to address these issues look healthy and are likely to succeed. The very short growth time due to the ARES fundamental mode is increased to a more reasonable 1.6 ms by increasing the stored energy in the ARES cavities (R/Q decreased from 15 to 9 ohms), which reduces reactive beam loading detuning from 65 to 45 kHz in LER. This requires modifications to the coupling between the ARES cavities. The coupled-bunch modes will be damped by a bunch-by-bunch longitudinal damper using a Daphne type kicker with a damping time of about 1 ms; adequate for b) and c), but marginal for a).

The existing mode -1 damper using the RF system will be upgraded to a much faster damping rate. A detailed plan on how to achieve this was not presented. It is suspected that the group delay of the present narrow band signal processing of the mode -1 damper does not permit a fast enough damping rate to damp the τ = 1.6 ms with an adequate safety margin (say 3 to 4). Another worry is how the transfer function of the heavily loaded cavity changes with high beam loading. Under heavy beam loading, the geometry of the klystron and beam RF vectors is such that an amplitude modulation of the klystron is required to achieve a phase modulation of the cavity voltage.

The Committee recommends that these issues be studied in more detail to demonstrate fast damping rates of the -1 mode in the LER at high current. Operating the cavity at a lower voltage than nominal can simulate the modifications of the klystron and cavity transfer functions due to heavy beam loading.

To provide the required increase in beam power, the existing ARES RF system will be modified such than one klystron only supplies one cavity instead of two, as only a modest increase in total voltage is called for. Later, additional ARES and SCC cavities will be installed, more than doubling the total number of klystrons: 28 klystrons per ring. The SCC cavities will be modified for increased beam power per cavity. The loss factor will be reduced from 2.46 to 1.69 pC/cavity by increasing the beam pipe diameter (150 to 220 mm). The HOM power handling capability will need to be increased to 57 kW per cavity. These modifications allow for the increased beam power, while maintaining an acceptable increase in total HOM power and beam gap transients.

To reduce the beam gap transients at the higher currents, the ion clearing and abort gap will be reduced from 5% (0.5 μs) to 2% (0.2 μs). The implications of the reduced abort gap were not presented at this meeting.

12) ARES upgrade

The ARES upgrade and R&D plans that were presented look solid and well justified. The coupling between the Accelerating cavity and the Coupling cavity needs to be increased to increase the stored energy. R&D is in progress to modify the waveguide HOM dampers to cope with 80 kW of HOM power per cavity and to test the bullets with a higher power L-band klystron. Also the 'Grooved Beam Pipe' HOM loads need to be tested to 20 kW per cavity. They may possibly evolve into the "Winged Chamber" HOM loads already used for the movable mask HOM loads. These need to be tested for power levels up to 5 kW per absorber (bullet). The input coupler will need to be upgraded and tested up to 1 MW, and a test stand to provide this power is being set up. There is a problem with single surface multipacting that will be addressed by a TiN coating of the outer conductor of the coaxial line of the input coupler.

13) SCC upgrade

The two key issues for the superconducting cavities will be the increase in HOM power that needs to be dissipated in the ferrite loads, and the need for a 220 mm gate valve occasioned by the increase in the size of the beam tube. The existing design of the ferrite-loaded damper is thought to be limited to below 60 kW by the need to keep the ferrite temperature below its Curie point at 280°C. Although this problem is real, a test stand has been set up to obtain more information to guide redesign, and an effective solution is likely.

Higher Order Mode power heating of the new gate valve is also a real issue that would benefit from application of additional engineering resources.

14) Klystrons

There are 26 klystrons currently in use at KEKB. The klystron lifetimes have been good, with tube lifetimes of order of about 18 thousand hours for the Philips tubes and about 47,000 hours for the Toshiba tubes. One Toshiba tube is still working after 73,000 hours.

A recent Toshiba klystron has reached 1.3 MW output power in a bench test, a world record. The window of that klystron operated well at 1.3 MW, and has a special design and cooling mechanism.

There has been much work to increase the power capability of the output windows. Using a test area, the klystron group has successfully developed a coating procedure for the TiNxOy layer that provides for the best surface structure and high resistivity. This anti-multipacting coating is optimized at about 100 angstroms.

The number of RF stations will increase with SuperKEKB up to 58, 32 more stations than are now present. With this large number of tubes and with the additional tubes needed to replace failed klystrons over the upcoming years at the existing KEKB, there is some concern that the klystron production rate in industry may not keep up with demand. Careful production planning will be needed.

15) Vacuum system upgrade

The beam parameters for the HER and LER vacuum system upgrade are 4.1 A and 9.4 A respectively with a total of 5,018 bunches. The key issues to be addressed are the intense synchrotron radiation, the high bunch currents and the very large total stored current. With the bunch length of 3 mm, impedance considerations and HOM power losses dictate the design of the vacuum system.

With the large number of bunches, the current per bunch is less than at present and is not expected to pose problems. Nevertheless, in order to add some safety, it is recommended that the vacuum system design should be more conservative and should be based on a larger bunch current, which needs to be defined.

The vacuum upgrade assumes that the present limitations by the electron cloud instability has been overcome and that this effect no longer limits the minimum bunch spacing. It will be essential to start an intensive research program to meet this challenging goal with the aim of exploring a variety of possibilities.

The main hardware of the upgraded vacuum system for both rings is a completely redesigned copper vacuum chamber with an antechamber. The choice of the antechamber concept offers the possibility to absorb the intense synchrotron radiation distributed along the cooled face of the chamber and thus far removed from the beam. It has been shown that photoelectrons produced in the antechamber no longer reach the beam with the addition of a solenoid field around the beam pipe, and their contribution to the electron cloud will be suppressed by more than two orders of magnitude (a factor of 300 has been deduced from the measurements).

Unfortunately, direct measurements in the LER have shown that the number of secondary electrons originating in the beam duct proper will still be sufficient to trigger multipacting. It will be essential to address this problem of secondary electrons.

Beam induced outgassing imposes a very effective pumping system with the very large flux of synchrotron radiation photons. A combination of ion pumps and NEG pumps has been proposed in the present design, with the NEG ribbons positioned above and below the antechamber. The total pumping speed has been estimated to be sufficient to achieve the required pressure of 5 10-7 Pa. However, the pumping capacity is small because of the limited quantity of getter material, and hence the interval between the reconditioning of the getter appears impractically short. It will be important to improve this situation by either increasing the getter capacity or by adding more pumps to the system. This is an entirely new regime of beam currents and may also need a new concept for the vacuum pumps.

The proposed design of an electron beam welded copper chamber is technically very challenging, since it has to meet very tight mechanical tolerances in addition to the ultra-high vacuum requirements. A prototype chamber has been tested and installed in the ring. The wall thickness of approximately 6 mm raises some concern, since it reduces the height of the antechamber.

Since the chambers have to be mounted in the magnet gap mechanical tolerances are very tight, and the Committee is concerned about the very limited space for the NEG ribbons.

Low HOM losses and small impedance represent very stringent requirements for the design since any section change must be kept very small. All components like flanges, bellows and vacuum valves are critical items because of the very large beam currents. The antechamber requires tapered end sections for impedance reasons. It is necessary to define a maximum step size for the design of the vacuum hardware and to specify an acceptable angle for tapered cross section changes.

The LER bending magnets produced a synchrotron radiation fan that could hit the downstream bellows and the quadrupole chambers. The layout should ensure that this is not the case and, if necessary, a shift of the bending magnets towards the upstream quadrupole could improve the situation.

A novel design of a comb RF-bridge for the bellows was presented. The design looks very promising and should guarantee a smooth cross section of the beam aperture. The Committee agrees that the proposed design should be adapted to different cross sections, and it would be desirable to obtain a larger stroke and more flexibility. In-situ testing of this new RF-bridge design for the expansion bellows has been very satisfactory.

Movable masks and HOM dampers require new solutions since the estimated power values are prohibitively large. The proposed design with a ceramic rod support must guarantee that electric charge-up of the device is prevented

Some further optimization of pumping slots is recommended in view of the 3 mm bunch length. The actual design appears to have rather large slots and may not avoid the problem of RF fields penetrating into the pump duct and heating up the structure.

The Committee strongly supports the study of possible means of coating against multipacting, e.g. a getter film like that which has been adopted for the room temperature long straight sections in the LHC. This may imply baking to activate the getter coating. A method, which has been tested in the laboratory at CERN, has been to produce carbon films using glow discharge with a suitable gas (Freon).

Both measurements and simulations of the electron cloud have shown that it forms vertical stripes in the dipoles. A possible means to reduce the intensity of the electron cloud could be to introduce slots through which electrons can escape and reach a clearing electrode that is shielded from the beam.

The Committee notes that the proposed design pressure of 5×10^{-7} Pa may not be sufficient to allow control of fast ion instabilities in SuperKEKB.

16) Interaction Region upgrade overview

The luminosity upgrade of SuperKEKB is based on three principles: more current, crab crossing, and lower beta functions in the interaction region. It is proposed to reduce the vertical beta function from 10 mm to 3 mm in both rings, which requires a reduction of the bunch lengths from 5 mm to 3 mm. The proposed horizontal emittances of 24 nm and the horizontal beta functions of 20 cm have been optimized using strong-strong beam-beam simulations. The crossing angle has to be increased from 22 mrad to 30 mrad in order to separate the beams sufficiently before the first aperture.

No simulations of parasitic collisions were presented, and these should be computed for the full number of bunches.

The physical aperture of the ring becomes too small to accept the current positron emittance of the linac so that a damping ring for positrons becomes necessary. This leads to positron emittances in the linac that are half the electron emittances. It is planned to implement the new IR design several years before the lepton species are exchanged in the LER and HER. Therefore the new IR is specified to accept the larger electron emittance in the LER as well as in the HER. It is recommended to study whether the IR design could be improved if it only had to accommodate the final choice of lepton species. Furthermore, it is recommended to study how the IR could be improved if the electron beam would also be damped in the damping ring. The required injection and extraction systems for the reverse direction of the electrons in the damping ring could be worth the investment.

Heating of IR components due to HOMs will become more pronounced with shorter bunches and needs to be studied. Studies of heating due to synchrotron radiation hitting IR components has started, but needs to be performed in much more detail including CSR and scattering of radiation. Studies of detector backgrounds also need to be added, including electron loss, secondary electrons, and possibly Compton scattered radiation.

In the current IR upgrade plans, the boundary between the beam line magnets and Belle is not changed, making major changes in Belle unnecessary. Nevertheless it is recommended to proceed with Belle upgrade plans simultaneously with KEKB upgrade plans so that the timing can be synchronized.

17) Superconducting magnets

The SuperKEKB design team has made excellent progress in designing new magnets for the Interaction Region, including a novel 6-layer design for QCS. This design has favorable effects on the operating margin of the refrigerator and ideally produces a quadrupole field with low harmonic components. The newest design better balances the offsets of the magnetic center between QSCR and QSCL magnets. A 2-section anti-solenoid has been designed to reduce the longitudinal forces to acceptable values. The influence on the field in the BELLE tracking volume is similar to the present IR magnets. This design has the potential to offer challenges in construction and operation and the Committee recommends early prototyping of the magnet.

The upgrade of the IR design also calls for a reduction on the distance from the IP to the final focusing quadrupoles. To achieve this, the team has had to come up with a design that embeds the quadrupole inside the compensation solenoid. The present solution is designed to be compact and to have minimum electromagnetic forces by using an innovative split solenoid. At this time, the design has all been done using 2-D simulations. The Committee recommends that it be checked with 3-D codes as soon as possible, followed by prototyping of the compensation solenoids so that they can be assembled with the QCS to confirm both magnetic and mechanical designs.

Based on the design of the magnet and experience with the present superconducting quadrupoles in the KEKB IR, the field harmonics are likely to be acceptable. The field quality is critical with the large (300-400 m) vertical beta in these quadrupoles and the effects of conductor placement errors should be evaluated.

The Committee also recommends that the design team estimate the magnitude of the flux of high-energy Compton-scattered synchrotron radiation photons contributing to heating of the IR region superconducting magnets.

18) Special magnets

A preliminary design of the special magnets for the SuperKEKB IR was presented in this meeting. There are 4 special magnets for HER and 2 for LER. The design parameters of these normal conducting magnets are closely related to the crossing angle, and the beam aperture, acceptance and aperture for synchrotron radiation look reasonable. Due to the larger crossing angle of 30 mrad, the space between QC1 and detector is very tight, since the QCS helium transfer line, support table, vacuum chamber, etc. must also be installed in this space. Hence the Committee recommends that further design efforts on QC1 and QC2 should be made, including the leakage field effect on QC1 magnets, and the interference with the vacuum chambers, Belle detector, and the support system.

19) Optics upgrade

The KEKB lattice design is sufficiently flexible that the arc lattice does not require significant modifications for SuperKEKB, so essentially all the modifications occur in the IR. The present optimization suggests that the beta x* should be reduced from the present 30 cm to 20 cm, and the crossing angle should be increased from 22 mrad to 30 mrad. The Committee is pleased to see these study efforts, and suggests that it be continued as it expects that the design will continue to evolve.

One issue of particular concern is the optics requirement to provide a short 3-mm bunch length. The present approach is to provide the short bunches by using a small momentum compaction lattice. However, this would only work if (a) the microwave instability is well under control, (b) the reduced synchrotron tune does not make synchro-betatron resonances worse and (c) the dynamic aperture has been fully evaluated. These questions will require more studies to settle. The Committee suggests that some experiments be performed to explore the feasibility of short bunches with a small momentum compaction lattice.

Locations exist for the possible installation of crab cavities in the IR. The betatron phase advances are slightly off, and the beta function is too small. More work is needed to make sure this option is optimized in the lattice design.

The design as presented provides adequate, but tight, dynamic aperture for both rings. More work is needed to increase the dynamic aperture, particularly since the dynamic aperture is expected to deteriorate when various error sources are included. If necessary, sextupole movers may be considered.

It is not clear whether the optics must satisfy the condition that dispersion must vanish at the crab cavity. The Committee suggests reviewing the beam dynamics of this issue. In the same review, the strength of synchro-betatron coupling due to crab cavity should be included.

The RF transient in the bunch spacing due to beam loading will cause a bunch-to-bunch separation of ±14 microns. The effect of this separation on beam-beam interaction should be studied, perhaps by simulation.

20) Beam Instabilities

The Electron Cloud Instability (ECI) has been the major problem in LER during the commissioning period. To achieve the SuperKEKB parameters, the beam pipe will be seriously modified to suppress the electron cloud. The recent results of simplified simulations of the electron cloud predict stability of the design bunch. However, a realistic simulation accounting for the antechamber shape (and the solenoid field imposed) is highly advisable as a next step.

A preliminary estimation of the resistive wall effect has been carried out, even before the impedance budget becomes available, including all the new components to be designed. The Closed-Orbit Instability threshold estimation is optimistic, however the safety margin of its threshold is surprisingly small for the design beam intensity of 6×10^{14}! Detailed studies of this effect should be pursued.

On the other hand, the growth rate of the Coupled-Bunch Instability due to resistive wall is found to lie well within the damping capability of the bunch-by bunch feedback system. In view of the important limitation caused by this fast growing instability, ways to increase the useful gain limit of the transverse bunch-by-bunch feedback systems should be investigated. Having four systems with feedback delays of a quarter of a turn instead of the present one turn system (or effectively 1.5 turns with 2 equal taps) could potentially result in four times faster damping rate, but straight signal paths cutting across the arcs must be provided to match the beam flight time. This also assumes that no power limit will limit the gain. To confirm the expected gains, experiments should be carried out to compare the measured maximum damping rates of a one-turn delay system with the optimum gain that can be expected from theory.

The ion instability for electrons in the LER (rather than in the present HER) is shown to be detrimental to the vertical emittance in spite of the fact that beam loss is likely to be prevented by the feedback at its gain limit. These results put a question mark on the polarity switch proposal. The Committee recommends clarifying the pros and cons of the polarity switch as soon as possible. It is suggested that a controlled vacuum leak experiment be designed and performed. Results can then be extrapolated to provide more guidance for the SuperKEKB charge switch scenario. Beam shaking can be considered in this exercise.

The detailed short-bunch feasibility study has high priority to justify the upgrade plans. The Committee recommends putting the emphasis on obtaining a detailed impedance budget. The impact of the Coherent Synchrotron Radiation (CSR) on the short bunch stability should also be studied, with a complete account of the transient CSR shielding effects, using the CSR shielding code now available at KEK.

21) Beam diagnostics system upgrade

The present KEKB has a complete variety of beam diagnostic techniques, and they performed successfully during the commissioning period. Special mention is due to the gated measurements of the bunch parameters (size, tune) as a function of its position in the bunch train. These measurements were very efficient for understanding the electron-cloud effects.

The high-current operation of the SuperKEKB presents a challenge to existing diagnostic techniques, both RF and synchrotron radiation based. The serious R&D program presented to the Committee is aimed at improvement of diagnostics and making it compatible with the design parameters of SuperKEKB. The Committee concurs with the diagnostics R&D program and recommends speeding up the development and testing of the prototype diagnostic units at the existing KEKB rings.

The Committee puts the emphasis on continuing machine studies on bunch lengthening (streak-camera, other techniques), and improving the bunch-length measurement accuracy, in view of the short bunch lengths needed for the SuperKEKB.

22) Installation

A preliminary time schedule was presented in this meeting for the design, construction and installation of vacuum system, magnet system, RF system, BPM system, IR vacuum and IR magnets and utilities for SuperKEKB. Most components of these systems were listed in the schedule. The Committee recommends that the schedule for the damping ring and linac upgrade be integrated into the schedule, and the operating schedule and beam performance profile should also be included to have a clear and complete time schedule for the whole SuperKEKB plan.

The schedule showed that the major production period would be two years after the start of the project, with installation a year later. The most critical issue in the installation may be the replacement of all vacuum chambers in 14 months. However, by the estimation of time taken to remove the upper halves of about 1250 magnets, to replace about 2000 beam pipes with new ones, and to re-install the upper halves of these magnets, it seems to be possible to finish this job within this tight time schedule. However, the additional installation time required with the new bellows and RF shields should be further investigated. A more detailed and complete time schedule is foreseen in the near future.

23) Linac upgrade: overview

The injection system will also be upgraded to provide the very high beam currents in the two rings; in particular, both rings will be injected with 2-bucket beams. A flux concentrator will be installed on the positron target. For charge switching, the positron beam will be sent to a damping ring at 1 GeV, and the following linac will be C-band with 42 MV/m acceleration gradient, twice that of the S-band linac. New modulators of a much more compact design are needed because the number of klystrons is to be doubled from 24 to 48, while the klystron housing is limited in space. A waveguide resonant ring was built to test the window breakdowns. These R&D studies have been continuing well and the Committee finds them satisfactory.

A C-band accelerator module has been high power tested and was found to be mostly satisfactory. The only problem concerned the input coupler that breaks down near the peak power. A more rounded coupler design should solve this problem, and will be incorporated in the second C-band prototype. The Committee looks forward to the resolution of this problem.

24) Linac upgrade: C-band linac progress - RF source

Two C-band RF assemblies have been designed, constructed and tested, and one of them has been successfully used in the high power test and beam test for the first prototype of the C-band accelerating structure.

A lot of present S-band components of the RF assembly, such as many parts of low level system, pulse transformer, PFN, thyratrons, etc., are reused in the C-band RF assembly for the cost reduction.

The C-band modulator is well designed to be compact, using an inverter power supply instead of the original large charging system. Hence the total 48 C-band RF units can be installed in the same space of existing 24 S-band RF units. The measured pulse stability has reached its design value of ±0.15%, but the flatness from pulse to pulse of 1.3% (peak-to-peak) is larger, caused by an unstable thyratron. After changing the thyratron, the stability was drastically improved.

A new type of C-band RF window has been developed. Unlike the pillbox type window, it uses a mixture of two modes (TE11 and TM11) to generate a traveling wave in the ceramic of the window to lower the electric field strength at the edge of the window and reduces the electron emission to help avoid breakdown in the window. This window has been successfully tested using the newly constructed C-band high power resonator ring.

The Committee congratulates the KEKB Linac RF group for the good progress in the C-band RF system development, and recommends the further studies of improving its stabilities and reliability.

25) Linac upgrade: C-band linac progress - accelerator section

A C-band accelerating structure has been developed in order to double the accelerating gradient for the increase of the positron energy from 3.5 GeV to 8.0 GeV. The first proto-type of 1-meter C-band structure is designed as a scale-down of the present S-band 2-m structure, and has been constructed, high power tested and successfully beam acceleration tested with the acceleration gradient of 42 MV/m. The Committee congratulates the KEKB Linac Group for this impressive progress since last review meeting. The remaining problem with this structure is RF breakdown around the input coupler, which will be improved in the 2nd prototype structure.

The Committee encourages further work to develop a 2-meter C-band structure, which will provide a complete test of the proposal for the future positron energy upgrade.

26) Linac upgrade: beam instrumentation

Beam energy and position feedback are presently used successfully in the linac. Energy spread can be measured with a fluorescent screen monitor at a location with dispersion, but the measurement is destructive. Feedback to stabilize beam energy spread is highly desirable.

An eight electrode strip line monitor with associated acquisition and signal processing has been developed which allows measurement of the quadrupole moment with respect to the beam centre $\langle x^2 \rangle - \langle y^2 \rangle$ and eliminates the contribution from position errors $\langle x \rangle^2 - \langle y \rangle^2$ present in the quadrupole moment with respect to the pick-up centre. If dispersion is sufficiently large, the energy spread will make a dominant contribution to the quadrupole moment measured thus allowing a non-destructive monitoring of the energy spread.

Feedback to correct this is planned, but the details of how to use this signal to correct the causes of momentum spread was not presented. Usually the momentum spread is minimized by maintaining the bunch on the RF crest. It may be difficult, but not impossible, to use the energy spread signal from the quadrupole monitor to correct the phase of acceleration.

As an alternative feedback scheme to minimise the energy spread, the modulation scheme implemented at Jefferson Laboratory could be considered. The accelerating phase is given a tiny modulation with a low frequency signal and the resulting energy modulation is measured at a dispersive location by synchronous detection of the position modulation. The off-crest phase (with sign) is proportional to the first harmonic of the position modulation, so it can be used to correct the phase in the right direction. (See Tiefenback, Lebedev, and Musson, PAC 1999).

In any case the non-destructive monitoring of the momentum spread by the quadrupole moment is extremely useful as it permits the measurement of differences between the two bunches. At Jefferson Lab thin foils and OTR are used for non-destructive monitoring, however these techniques do not give information on the time structure and cannot separate the two bunches.

27) Design of damping ring

A Damping Ring (DR) is proposed for use with the injector of SuperKEKB to reduce the emittance of the positron beam before it is subsequently accelerated in the linac and injected into the SuperKEKB positron ring. The reduced emittance will allow for cleaner injection, and thus an enhanced filling time and lower detector backgrounds. The damping ring will be located midway along the linac and have an energy of about 1 GeV.

The positron beam from the upstream linac that enters the DR will have a large energy spread (about ±4%) that needs to be accepted by the DR. The acceptance will be greatly improved by the addition of the proposed Energy Compression System ESC to reduce the energy spread to ±1.5 % that can be safely accepted by the DR. Similarly, a bunch lengthening system on the beam line after extraction from the ring but before the linac is used to match the bunch length with the C-band linac. The DR magnetic lattice design is a new design and is very reasonable. This design gives a factor of 100 reduction in beam emittance. Four bunches will be stored at a time and two bunches will be produced at a rate of 50 Hz.

The Committee supports the planned mode of operation where the linac and DR can be operated in pulse mode where either beam can be injected continuously into the SuperKEKB. A damping ring for the electrons would also allow for an improved rapid injection of the electrons into the high-energy ring and lower backgrounds but is not planned at this time. The Committee suggests considering the use of the same damping ring for both electrons and positrons while alternating the injected beams on successive pulses.

28) Beam Lifetime at SuperKEKB

The various contributions to the beam lifetime at SuperKEKB were presented, including the effects of quantum fluctuations, Touschek, beam-beam, luminosity, and vacuum. The combined overall lifetimes are about 20 and 50 minutes with and without the beam-beam effect, respectively, for both beams. These values require that the beams be continuously injected to maintain luminosity. The Committee recommends that the required injection rate (including all of the efficiencies) be checked against the planned production rate of particles from the upgraded linac and damping ring complex. Furthermore, the Committee suggests that the required vacuum pressure level needed in each ring be carefully specified so that the vacuum designers can adequately plan.

Appendix A

KEKB Accelerator Review Members

Andrew Hutton	JLab	Chairman
Alexander Chao	SLAC	
Warren Funk	JLab	
Oswald Gröbner	CERN (retired)	
Georg Hoffstaetter	Cornell	
Won Namkung	Postech (Unable to attend)	
Fleming Pederson	CERN	
Eugene A. Perevedentsev	BINP	
David Rice	Cornell	
John Seeman	SLAC	
Wang Shuhong	IHEP	
Katsunobu Oide	KEK	Secretary, Accelerator
Masanori Yamauchi	KEK	Secretary, BELLE

Appendix B

Agenda of the Eighth KEKB Accelerator Review Committee

Feb. 16 (Mon.)		
8:30- 9:00	Executive session	
9:00- 9:15	Welcome	Y. Totsuka
9:15- 9:30	Overview of KEKB project	K. Oide
9:30-10:10	KEKB status	H. Koiso
10:10-10:30	Break	
10:30-11:00	Experience on High Current	Y. Suetsugu
11:00-11:30	Physics of BELLE, today and tomorrow	M. Hazumi
11:30-12:00	Upgrade plan overview	Y. Ohnishi
12:00-13:00	Lunch	
13:00-13:30	Beam-beam interaction	K. Ohmi
13:30-13:50	Crab cavities: Status & Plan	K. Hosoyama
13:50-14:10	Crab cavities: Cryostat R&D	H. Nakai
14:10-14:30	Crab cavities: Nb-Cu coaxial coupler R&D	K. Nakanishi
14:30-14:50	Crab crossing optics	A. Morita
14:50-15:10	Crab cavities for high currents	K. Akai
15:10-15:30	Break	
15:30-15:50	RF system upgrade	K. Akai
15:50-16:15	ARES upgrade	T. Kageyama
16:15-16:40	SCC upgrade	S. Mitsunobu
16:40-17:00	Klystrons	S. Isagawa
17:00-17:30	Vacuum system upgrade	Y. Suetsugu
17:30-18:30	Executive session	
18:30-20:00	Reception	
Feb. 17 (Tue.)		
8:30- 9:00	Executive session	
9:00- 9:20	IR upgrade overview	Y. Funakoshi
9:20- 9:40	Superconducting magnets	N. Ohuchi
9:40-10:00	Special magnets	M. Tawada
10:00-10:20	Optics upgrade	H. Koiso
10:20-10:40	Break	
10:40-11:05	Beam Instabilities	H. Fukuma
11:05-11:30	Beam diagnostics system upgrade	J. Flanagan
11:30-11:50	Installation	R. Sugahara
11:50-13:00	Lunch	
13:00-13:20	Linac upgrade: overview	T. Kamitani
13:20-13:40	Linac upgrade: C-band linac progress - RF source	S. Michizono
13:40-14:00	Linac upgrade: C-band linac progress - accelerator section	T. Kamitani
14:00-14:20	Linac upgrade: beam instrumentation	M. Satoh
14:20-14:50	Design of damping ring	M. Kikuchi
14:50-15:10	Beam lifetime	Y. Ohnishi
15:00-18:00	Executive session	
18:00-20:00	Working dinner	
Feb. 18 (Wed.)		
8:30-10:30	Executive session	
10:30-11:00	Interaction with KEKB staff members	
11:00-11:30	Closing	