The Thirteenth KEKB Accelerator Review Committee Report

November 29 – December 5, 2007

Introduction

The Thirteenth KEKB Accelerator Review Committee meeting was held on November 29 – December 5, 2007. Warren Funk and Flemming Pedersen were unable to attend this meeting, and Wang Shuhong was only able to attend for one day. Heino Henke has resigned from the Committee. Appendix A shows the present membership of the Committee.

The meeting followed a new format, with two separate parts. The first part of the meeting was spent in the Control Room with the Committee members observing the machine maintenance recovery and downloading and testing of a new machine optics. The Committee members followed all of the steps leading up to colliding beams of high luminosity, and were able to interact directly with the KEKB staff who were actually performing the tuning operations, pose questions and obtain a good understanding of the processes. The second part of the meeting consisted of oral presentations by the KEKB staff members and discussion by the Committee members. The Agenda for the meeting is shown in Appendix B.

The Committee was as always impressed by the high standard of the talks, both the technical content and the presentations themselves. The KEKB staff showed great confidence in their ability to demonstrate tuning techniques on the machine in real time, and the Committee was impressed with the ingenuity and complexity of the tuning algorithms. 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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10) Wiggler Antechamber/Collimator R&D

Executive Summary

Foreword

In the past nine months, all attention has been focused on commissioning KEKB with the crab cavities and increasing the luminosity for BELLE. The world record for luminosity is still 1.71 x 10^{34} $cm^{-2}s^{-1}$ established in November 2006 without the crab cavities. The initial dedicated machine studies of collisions using the crab cavities started in February 2007 and focused on few-bunch operation. These studies resulted in the highest specific luminosity ever observed in KEKB. Higher current running was then tried and the design luminosity was reached again on June 22, 2007. High current operation resumed in October after warming up the crab cavities to outgas them. The luminosity has climbed rapidly since then, and BELLE data taking has co-existed with machine optimization. The peak luminosity that has been attained with crab crossings is 1.47 x 10^{34} $cm^{-2}s^{-1}$, which is not as high as the previous record but a major accomplishment for commissioning such a major new operating mode.

The Belle detector reached an integrated luminosity of ¾ ab^{-1} on November 25, 2007, a major milestone. The Committee congratulates the entire KEKB project staff on this new record. The BELLE detector has published, or submitted for publication, a total of 242 papers in refereed journals (206 at the last meeting).

The meeting was devoted to the present status of KEKB, the accelerator physics limitations to the luminosity and, in particular, progress with the crab cavity. There was also one talk on the vacuum system R&D for upgrading KEKB to a luminosity of 6-8 x 10^{35} $cm^{-2}s^{-1}$. The KEK Director General, Prof. Atsuto Suzuki, presented the Roadmap for the future of KEK, which he is proposing to the funding agencies. The Committee was pleased to see that SuperKEKB was an integral part of this plan, with construction starting in 2009, immediately following the closure of KEKB, foreseen when BELLE has accumulated an integrated luminosity of 1 ab^{-1}. The Committee understands that fiscal constraints may not allow all elements of the Roadmap to be implemented, but strongly supports the inclusion of SuperKEKB in the planning.

The new (and longer) format of the Review allowed the Committee to observe first-hand the dedication of the KEKB staff supporting machine operations and the high quality of their work, which has led to the impressive results that have been achieved.

Recommendations

Last year, the Committee made many recommendations, and the KEKB staff has addressed all of them. Some of these have not been completed and are reiterated below, together with recommendations for continuing the work that has already been started.

1. The Committee endorses a major luminosity upgrade (SuperKEKB) aimed at a luminosity of 8 x 10^{35} $cm^{-2}s^{-1}$ as part of the KEK Roadmap.
2. The Committee strongly endorses the plan for simultaneous injection in KEKB rings, currently foreseen for October 2008.
3. The Committee recommends continuing the extended alternating high and low beam current studies to improve the chances of success with crab cavities and to make sure there is sufficient beam study time to obtain satisfactory results and complete understanding. BELLE could take data during the high current running.
4. The Committee recommends continuing the studies of the accelerator physics issues and development of the specialized components needed for SuperKEKB.

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

5. The Committee feels that the KEKB accelerator team should take some time to contemplate results and possibilities without daily distractions. Therefore we recommend holding a 2-3 day retreat away from the lab during winter shutdown to brainstorm ideas for luminosity improvement. Computing facilities and access to data should be available.
6. The BELLE collaboration should work with the KEKB team to make a strategy to optimize the integrated luminosity between now and the end date of March 2009 and to develop plans, if any, to run on other Upsilon resonances.
7. The Committee recommends that every effort is made to speed up the present luminosity optimization algorithms, to improve the probability of convergence.
8. The Committee recommends finding a parameter (luminosity) optimization algorithm which works rapidly at the peak luminosity to improve parameters. This algorithm should be combined with trying, from time to time, very different starting conditions to avoid local minima.
9. Clarify the bunch-by-bunch orbit displacement effect on the luminosity and study its relevance to the luminosity limitation.
10. Beam-beam simulation will be critical to the success of KEKB. The Committee recommends integrating the simulation efforts with the machine operation as a guide to improving luminosity.
11. Since the feature of a sharply-peaked optimum luminosity peak on a broad shoulder is so critical in guiding the machine luminosity optimization, it should be confirmed with another established beam-beam simulation code.
12. Provide the full set of strong-strong collision simulation results relevant to the gated bunch spectra measurement in order to improve their interpretation. Consider the potential application of the gated tune measurement technique for the luminosity optimizations in operation.
13. The search for the gas source in the LER crab cavity should continue. The starting point should be a repetition of a global leak check of the cavity assembly followed by an in depth search of all subcomponents.

Findings and Recommendations

Section 1: Control Room Activities

a. Daily Commissioning Meetings

A commissioning meeting is held every day to go over the progress in the preceding 24 hours. Members of the Committee attended six of these meetings. Exceptionally, the meetings were held in English for the benefit of the Committee, and this was extremely helpful. The meetings were detailed and focused on the problems as well as any new insights that had been gained. Overall, the meetings were very impressive.

b. Recovery from maintenance and installation of new optics

A well organized procedure efficiently brings the KEK-B machine up from the bi-weekly maintenance shutdown. Preliminary steps include a review of activities during the shutdown to identify any specific components requiring special attention during tuning and running magnets through a standardization cycle. Once the electron beam is established to the end of the linac, the beam profile monitors are swept to document emittance and optics. The linac cavity parameters are tuned to set the beam energy and minimize energy spread, and then the orbit feedback may be enabled. This procedure is repeated for two-bunch positron operation. Once the beams reach the end of the transfer line the energy spread is once again optimized. This whole procedure proceeded very efficiently while Committee members were in the control room.

Minimal tuning was necessary to accomplish injection into the storage rings, whereupon beam position monitor (BPM) calibration proceeded with 30 mA total beam current in each ring individually. BPM cables up to 240 m in length introduce long term drift in the effective gain for individual pickup buttons, causing changes in gain and non-linear characteristics of the system. Four dipole correction elements in each ring (0° and 90° phases for vertical and horizontal planes) are stepped through a rectangular grid pattern and all BPMs acquire data for each point. While the physical space swept out varies at each detector, the nonlinearity is measurable to sufficient accuracy. The reduction in BPM errors is significant.

Comment: Recording betatron tunes at each corrector setting can provide useful information on orbit-dependent tunes, specifically checking proper sextupole operation.

The BPM gain is calibrated by comparing the off-set beam position evaluated from the signals of three of the four individual buttons to calculate the position in four different ways. The consistency check is done by putting an upper limit on the standard deviation of the four results. Those BPMs exceeding the limit are rejected in further orbit analysis.

Trim coils on quadrupoles are switched to a few trim power supplies permitting measurement of the BPM electronic offset with respect to quadrupole magnetic centers. A local closed orbit perturbation samples the quadrupole field at several positions while the kick from a small change in quadrupole field is measured by fitting the global closed orbit change. Because of long time constants to change beam position (for compatibility with the global closed orbit feedback system) the calibration rate is 3 minutes per quadrupole. Therefore BPMs are calibrated only when the need arises.

New optics are installed directly, controlling tunes with the feedback system, and are checked with an orbit response method. Typically, several sextupole candidate distributions are computed. Each is evaluated by the "bungee jump" technique – taking a 30 mA stored beam across the $2Q_x + Q_s = n$ resonance, selecting for minimum beam loss. This is normally only done for the LER.

38 fast position monitor circuits are installed in each ring to provide injected bunch position measurements and betatron phase advance data to check against the ORM optics measurements. The two optics measurement methods agree at the ±12% level in the LER and ±10% in the HER. Simulations suggest that closed orbit errors may be responsible for some of these differences. While Committee members were in the control room, a single gradient error was introduced using the trim windings on a quadrupole. The change in phase advance measured with the fast BPMs agreed well with the lattice model.

c. Performance optimization

Optimization of luminosity relies primarily on two techniques, scanning individual parameters and multi-parameter optimization using the simplex method.

Single parameter scans are performed for several critical interaction point parameters: 4 coupling parameters, vertical dispersion and dispersion slope, vertical waist position, and horizontal dispersion. Coupling and vertical dispersion control is realized through vertical beam positions at 16 sextupoles. Quadrupole current changes control the vertical waist and horizontal dispersion. On occasion the tilt (coupling) of the crab kick, vertical dispersion at the crab cavities, the crab angle and the coupling parameters $R_{2,4}$, may be scanned.

Some of the tuning parameters (horizontal and vertical collision offsets and angles) are in a continuous feedback loop, so the scan is actually performed by scanning the feedback target values. The scan speed is limited by luminosity monitor statistics and the need to measure each point at similar machine conditions – i.e., at the same currents. Thus only one point per injection cycle is possible, or about one every 5 minutes.

The simplex scanning technique dates back to 1965 and is an extremely robust algorithm which is, however, slow to converge. In the application on KEKB, 12 parameters are optimized, 6 for each ring: R_1, R_2, R_3, R_4, η_y, and η_y'. The method initially involves taking thirteen scans which takes about one hour. This is slow because the colliding beam currents are kept constant, so both rings must be topped up between each measurement. The algorithm then attempts to improve the parameter set which gives the lowest luminosity (which is counter-intuitive) and after about a shift the luminosity is maximized. Alternatively, the beam size of each beam is minimized at the collision point; this is somewhat faster but is less direct.

Comment: In all cases, the optimization starts from a condition with the horizontal position feedback maintaining the two beams offset from one another. This centers the colliding beams in the aperture, determined by observing beam loss as the offset is varied. It is difficult to understand why the aperture is not centered on zero offset, but it is not necessarily true that the luminosity peak is similarly offset. It would be worth trying to center the offset and re-trying the simplex optimization. This may result in finding a better operating parameter set for luminosity and may or may not also improve the aperture available for beam loss.

Comment: The simplex routine requires that a scale be applied to each variable. The criteria used to select this scale is the range over which the parameter can be changed without significant beam loss. The implicit assumption is that this is related to the luminosity optimization. It would be better to use information from the simulation to determine the scale for each variable. Starting from the optimum luminosity condition found in the simulations, vary each parameter individually and identify the "knee" in the luminosity curve. Use the parameter offset at the knee as the "luminosity" scale factor. This should do a better job of balancing the relative step size during the Simplex process.

Comment: Simulation of the KEKB machine optics with errors should be performed to estimate the relative size of the twelve tuning knobs. Comparing these values to the luminosity scale factor would allow ranking the tuning parameters by sensitivity. Single scan luminosity optimization should then use the tuning knobs in order of decreasing sensitivity.

Any optimizing algorithm depends on knowing that the conditions are stable over the time it takes to perform the optimization. If this is not the case, the optimization may never converge. The simplex algorithm in KEKB takes about a shift to converge and it is not at all clear that the machine conditions are sufficiently stable over this period. Optimizing the "green ratio" as the beam currents decay would significantly speed up the process, and the reduction in drift in other parameters would outweigh any effects from the lesser accuracy.

Recommendation: The Committee recommends that every effort is made to speed up the algorithm, to improve the probability of convergence on the best machine conditions.

During production running these tuning methods are employed continually, the exact sequence and parameters used are left to the discretion of the shift leader. Generally this results in a slow but positive increase in performance in any 8-12 hour period if machine conditions are not disturbed (e.g., beam aborts, equipment failure, earthquakes, or unexplained "glitches").

***Comment*:** As the performance profile becomes sharper minimizing perturbations to this optimization process and uncontrolled parameters becomes more critical. It is vitally important to assure that the procedures and control of parameters is sufficient to satisfy this condition.

Recommendation: Consider dedicated tuning periods with 100 bunches and slightly lower bunch current where parameter and simplex scans can be completed more quickly, and focusing efforts on finding the narrow peak in parameter space. High rate luminosity monitor would be useful.

d. Use of diagnostic systems

Several highly developed diagnostic systems are available, including wide angle Bhabha and bunch-by-bunch radiative Bhabha luminosity monitors, beam position monitors, gated transverse beam spectrum, imaging streak cameras providing x, s profiles for both rings, vertical and horizontal profile monitors (interferometers for high resolution), and beam loss monitors. We will not review these in detail here but will make a few suggestions for their use.

Comments:

Electron cloud activity may usefully be monitored occasionally by recording tune shifts along the bunch train – both rise time and saturated levels – as a function of beam current.

Installing a small number of fast counters by collimators would quickly give information on particle loss rates and bunch dependence. E.g., is poor lifetime in a given condition primarily because of loss of a few lead bunches.

Some enhancements to the gated tune spectrum monitor – averaging and flexible zoom features – may provide useful information on beam size at the interaction point, useful in confirming relative beam-beam parameters and understanding discrepancy between beam size measurement and luminosity. This might even provide a fast luminosity tuning monitor.

Improving statistics on luminosity monitoring would be useful. Perhaps one might find that some parameters could be tuned without disturbing the calibration factor of the fast radiative Bhabha monitor.

e) Crab Cavity Voltage Scan

The Committee was invited to observe the procedure for scanning the crab cavity voltages to find their optimum values for luminosity. The procedure, explained by our colleagues in the control room, is as follows.

First the crab voltages are set to their nominal values. The phase of the HER cavity is increased by 2°, followed by the same value for the LER cavity. This is repeated until 6° is reached. A difference in phase of 2° leads to a difference of -30µm in the beam-beam kick. If a 6° offset on both leaves the kick unchanged the cavity ratio is correct. If a change is seen then the ratio must be adjusted and the process repeated. This took about 20 minutes for one cycle. The order and sign of the changes is important. A wrong move leads to beam loss (HER orbit negative giving beam loss and radiation dump) and a time lost of ~ 45 minutes.

With the correct voltage ratio the voltages are scanned keeping the ratio constant. The observable is the total luminosity which can be acquired every 10 seconds. A number of measurements (twelve) for reasonable statistics are made at each voltage pair. Changing the voltages is the most time consuming part as only small incremental changes, to prevent cavity trips, are allowed at the present time. The total scan took about 60 minutes

It was impressive how easily and quickly the data was recorded and then presented in graphical form with curve fitting.

The result of the scan, carried out with 1.55 A in the LER and 0.81 A in the HER, gave a very clear optimum voltage pair 0.796/1.32 MV, very close to the previously found value of 0.784/1.30 MV.

f) Luminosity Operation

The KEKB accelerator is operated to produce B mesons for particle physics studies. The operation of KEKB has been exceptional for many years. The total delivered integrated luminosity to BELLE is the largest particle physics data sample in the world at over 750 fb^{-1}. This is a very significant achievement.

Recently, the control room efforts have been centered on delivering as much integrated luminosity to the BELLE detector while doing as much as possible to advance the efficiency of the crab cavity system along with the beam-beam effects to produce higher luminosity. At the present, KEKB has produced a peak luminosity of over $1.4 \times 10^{34}/cm^2/s$ with the BELLE detector and crab cavities operational. The near term luminosity goal is to get back to the former peak luminosity of $1.7 \times 10^{34}/cm^2/s$ and in the longer term to exceed this value by up to a factor of two.

The present operational mode is to produce data for BELLE but adjusting parameters slowly and parasitically to optimize luminosity and to find new better accelerator parameters. A simplex optimization code is used to find the best combination of 12 accelerator parameters. Six parameters are used in each of the Low Energy Ring (LER) and six in the High Energy Ring (HER). In each ring there are four interaction region coupling variables and two dispersion knobs. These efforts have kept the peak luminosity near the recent maximum.

More extensive accelerator studies have been tried periodically to increase the peak luminosity, with the recent concentration on changing the horizontal beta function at the interaction region. Definite luminosity changes and improvements have been seen as a result of these studies.

The simplex optimization code is designed to be very robust and not get stuck in local minima but, as a result, does not converge rapidly. Other algorithms exist which work constantly at the peak of the luminosity trying to find better condition although they may not be able to avoid local minima. The tuning and filling cycles of the KEKB accelerator make the iteration times long for the present optimization code and a more rapid code may well be better.

Recommendation: The ARC committee suggests finding a parameter (luminosity) optimization algorithm which works rapidly at the peak luminosity to improve parameters. This algorithm should be combined with trying, from time to time, very different starting conditions to avoid local minima.

Recommendation: The ARC committee suggests finding methods to reduce the time needed to refill the KEKB rings after a beam abort. A reduced time will speed the luminosity optimization as the optimum accelerator parameters likely drift with time during refilling.

Recommendation: The beam-beam simulation code should be upgraded to include the actual crab cavity and transport lattice to and from the interaction region with chromatic effects. These code improvements will likely offer new handles on the errors which can affect peak luminosity and the beam-beam parameters.

Recommendation: Vertical jitter has been shown to affect peak luminosity. A renewed effort should be made to understand all the sources of vertical jitter in both rings and possible reductions.

Recommendation: The beam-beam simulations show that smaller vertical emittances are better for beam-beam effects. The present vertical emittances are about 1% of the horizontal. The committee recommends trying to reduce the vertical emittance to about 0.5 % as the beam-beam simulation suggests about a 25% luminosity improvement with this reduction.

Recommendation: The luminosity responds to the tuning knobs. The knobs should be orthogonal as possible since non-orthogonal knobs makes it difficult to control errors in other parameters, which are sometimes very sensitive to small changes. The committee recommends checking the orthogonality of the IP tuning knobs and fixing them if needed. If the knobs are only partially orthogonal, then the very sensitive knobs should be scanned more often than the less sensitive ones.

Recommendation: Information from the position monitors should be fully exploited to understand transient and long term effects, as well as in the routine correction of BPM data.

Section 2: Presentations

1) Commissioning Progress before July

As reported by Koiso-san in the March, 2007 meeting of this Committee, the crab cavities were commissioned successfully, checking optics, crabbing angles, and beam stability. Even at this early stage (less than one month experience with beam) the vertical beam-beam parameter in the HER had increased by more than 50%. The work was performed with a limited number of bunches.

During the period from March 20 to June 30 covered in this section the beam currents were increased to production values, the horizontal emittance was varied, and the luminosity passed 10 /nb/sec. Crab cavity hardware development is covered in detail in another section of this report. During this period the voltage limits on the crab cavities were 1.0 MV for the LER and >1.7 MV for the HER cavity.

With an achieved luminosity greater than 10 /nb/sec the concept of crab compensation of crossing angle was validated. Beam-beam parameters were better balanced, with all being at or above 0.09. Beam currents when optimized were found to be closer to the energy transparency condition than with the crossing angle and the optimum vertical betatron tunes increased as predicted by simulation.

Specific luminosity performance quickly exceeded that with crossing angle, indicating that the geometric penalty was fully compensated. While the lower current specific luminosity was further improved, reaching a higher vertical beam-beam parameter ,the change of specific luminosity with current^2 was steeper than with crossing angle, intercepting the latter at a value around 1 mA^2. Strong-strong beam-beam simulations in fact indicated that the high predicted luminosity was easily compromised by small errors in any of several parameters.(e.g., 1 mrad crossing angle)

Higher LER and HER emittances were briefly explored; however, specific luminosity was unchanged and current limits only slightly changed. The original (zero current) emittances of 18/24 nm (LER/HER) were finally selected.

Because of the importance of the $2Q_x+Q_s$ resonance in the tune plane, and to reduce the bunch length, a negative momentum compaction optics was tried. This was successful in that the HER could be operated with horizontal tune below this resonance and the bunch length was reduced from 6 to 4.5 mm. However, overall luminosity was not improved and this optics was abandoned when a strong longitudinal oscillation was seen in the LER.

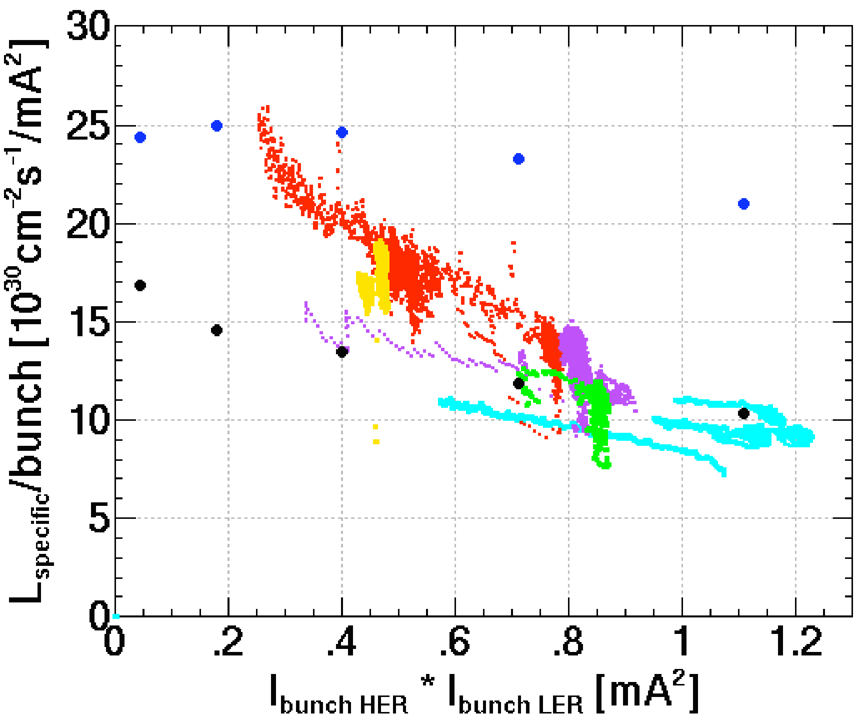
During this period an asymmetry in lifetime with respect to horizontal offset scans was observed. This phenomenon persists unexplained today.

An important early test result was the confirmation of the ability to store beam currents similar to before crab cavity installation if the cavities are detuned. This result reduces considerably the likelihood of having to remove a ring cavity from the ring due to poor luminosity performance.

Additional issues studied during this period included the reduction in dynamic aperture due to the beam-beam interaction (88 minute HER lifetime predicted at 1.2 mA/bunch) and the dependence of luminosity on the initial vertical emittance.

Comment: The Committee congratulates the KEKB staff and management on the excellent work in installing, commissioning, and understanding the properties of the crab cavities and the crab compensation process. During this period many aspects of this mode of operation were studied and the groundwork was laid for the developments that followed.

2) Commissioning Progress since October



KEKB restarted full intensity operation with crab cavities in October after the summer shut-down. During this period, bunch spacing was changed from 3.5 to 3.06, and ßx* changed from 68 cm to 90 cm. The present status is summarized in the figure above.

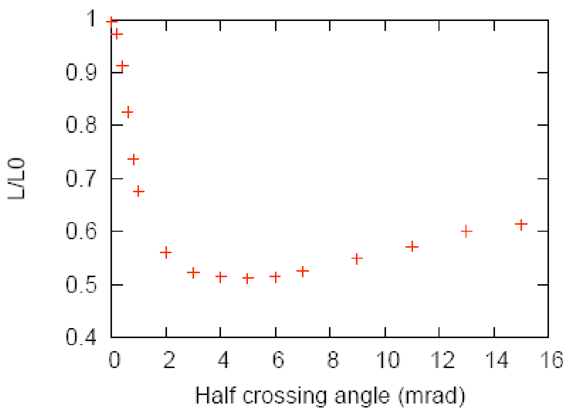
More specifically:

a. Simulation and the specific luminosity (L_{sp}) data agree for the case without crabbing.

b. Simulation predicts a gain of L_{sp} by a factor of ~2 with crabbing, yielding a maximum tune shift of 0.15.

c. With crabbing, L_{sp} agrees with simulation around $I_{bunchLER}$ * $I_{bunchHER}$ = 0.25 mA^2. Above these beam currents, it falls off rapidly as beam currents are increased, while below these beam currents, there is no evidence of agreement between data and simulations.

d. The beam lifetime deteriorates when the tune shift reaches ~0.08. The red data points are when beam lifetime reaches ~100 minutes.



e. Simulations show that L_{sp} is extremely sensitive to setting parameters. In addition to the list of many standard parameters such as beta*'s, betatron tunes, chromaticities, and beam collision orbit displacements, L_{sp} is found to also depend sensitively on crossing angle, orbit noise, and the 12 Knob-1 parameters. The parameters space is therefore huge, perhaps 24-dimensional in all.

f. Simulations indicate (already during the previous Review) that one needs to be very close to the optimum in order to find the optimum. Otherwise, a broad shoulder of L_{sp} is reached in the 24-dimensional parameters space, falling short of the factor of ~2 from the sharply peaked optimal value. Careful but lengthy optimization procedures have been designed and followed. So far no extreme sensitivity has been found, indicating we are not close to the optimum. Assuming that this picture is valid, the conclusion is that, with all the efforts invested, the red data do not represent the optimum values but rather the broad shoulder values.

g. Example of sensitivity (i): L_{sp} drops sharply when the crabbing angle is not exactly 11 mrad. Tolerance is ~0.1 mrad. Note that the crabbing angle measurements using streak camera has an error bar >> 0.1 mrad limited by the insufficient light from synchrotron radiation.

h. Example of sensitivity (ii): Simulation indicates a sensitivity to orbit noise, which seems to be consistent with the observation that L_{sp} improves when the orbit feedback gain is reduced.

i. The present effort concentrates on pushing for higher beam currents along the red curve. As mentioned, it is possible that we are just staying on the shoulder values, not the optimum values, of L_{sp}.

j. An apparent asymmetry is observed in beam lifetime when the horizontal collision orbit is scanned. The cause of this asymmetry is so far unidentified.

Recommendations

Instead of concentrating on pushing for higher beam currents along the red curve, it might be more critical to search for the sharply peaked optimum at fixed beam currents. At present, the "red ceiling" stands as the real critical path limiting the crab cavity performance. Investigations should emphasize how to break this ceiling at fixed beam currents instead of pushing for higher currents. Long bunch spacing (therefore low total currents) can be used in these investigations.

The above investigation could include: (a) finding the best optimization algorithm, (b) identifying the necessary diagnostics tools, (c) simulation including measurement errors and corrector setting errors, (d) simulation with "missing knobs", (e) understanding why Simplex scan so far did not yield the L_{sp} predicted by simulation.

- (a) finding the best algorithm: A simplex algorithm has been developed. This algorithm deals with all scanned parameters on an equal footing in contrast to a more traditional approach which deals with each parameter in single-parameter scans. Simulations indicate that both approaches give basically the same optimal L_{sp}. In an environment of a multi-dimensional shoulder with a sharply peaked optimum, however, the effectiveness of different algorithms might be very different. It is suggested that a combination of Simplex and traditional algorithms be tested on a wide range of parameters to look for much shortened turn-around times.

- (c) and (d) more simulations: To understand why simulations seem to produce much better optimum than actual operation so far, it is suggested that measurement errors and corrector setting errors be included in the simulation. Also, since the parameter set is never 100% complete, it is suggested simulating some cases with "missing knobs". If some of the scanned parameters are left out, can the optimum still be found in the simulation?

- (c) and (d) more simulations: Since the picture of a sharply-peaked-optimum-on-a-broad-shoulder (SPOOABS) is somewhat unexpected, and is so critical in guiding the next efforts, it is suggested that this feature be tested with another established beam-beam simulation code for benchmarking. Confidence in this picture will be substantially enhanced if another code predicts similar results.

- (e) Understanding the mechanism: So far, there is no experimental confirmation of simulation results except that they agree at the point $I_{bunchLER}$ * $I_{bunchHER}$ = 0.25 mA^2. To establish confidence of the simulation results, it is urgently needed to explore the region when beam currents are < 0.25 mA^2. The expectation is that data and simulations would indeed agree in this region, but this has yet to be established. Once confirmed, this study will also give a sharply defined beam-beam limit in KEKB.
- More on (e): If after some studies, the SPOOABS picture turns out not applicable, the next efforts should not be looking for the sharp optimum. An alternative approach would be to see if L_{sp} can be increased by relaxing on the beam lifetime requirement. In this picture, one assumes the red ceiling is simply due to some beam tails generated by beam-beam, followed by some aperture limitation. A test is suggested to relax the beam lifetime requirement to see if that would break the red ceiling. Along the same line of reasoning, intentional orbit deviation and/or scraper settings can be tried to study the aperture situation as needed. On the simulation front, it is suggested that a systematic investigation of beam-beam tails and beam lifetime be carried out, which so far has understandably not been the emphasis.
- Still more on (e): Considering the breaking of the "red ceiling" to be the critical path, it is suggested to push for higher L_{sp} fixed beam currents at 49-buch spacing. The result so far when the "green ratio" reached 110% is particularly encouraging in the sense that a substantial further increase by any means would be considered breaking the ceiling, and thus of great significance. Ways to further increase beyond 110% could include reducing β^*_x from 100 cm to 80 cm.
- Because of the operation near half-integer tunes, there are well-defined synchrobetatron resonances very near the working point, particularly $2Q_x + Q_s$ and $2Q_x + 2Q_s$ resonances. It is believed that these resonances are not driven by the crab cavities but by sextupoles and other nonlinearities in the lattice. It is suggested that the source of these resonances be first identified and calculated, yielding two strength coefficients: one "cosine harmonic" and one "sine harmonic". Two control knobs (a "cosine knob" and a "sine knob") could then be designed consisting of stringing up some lattice magnets (quadrupoles and/or sextupoles). These knobs can then be tweaked during operation to compensate for the driving terms of the resonance. Since these resonances are located close to the working point, their compensation might help to improve the beam lifetime.
- Concerning the apparent asymmetry of lifetime observed when collision orbits are varied, if it persists, it is suggested that effort be made to understand its mechanism. In case simulation is used to do this, it should emphasize understanding the mechanism rather than only getting the results to agree. One possible mechanism, for example, could be an aperture limit induced by the beam-beam displacement and/or kick.
- At present, the simulation runs are time-consuming. It is suggested to try to speed up the simulation procedure either by streamlining the code or by running a smaller well-selected set of cases. When a more efficient simulation code becomes available, it is further suggested that the simulations be more integrated into the actual machine operation. In particular, it could be used to guide the optimization procedures, or even to eventually become part of the control software.

3) Crab Cavity Operation

The crab cavity is now demonstrably a fully operational device working in the presence of high beam currents in both the LER and HER rings. Full congratulations must go to the team that has produced this excellent result.

At low beam currents 1.6/1.7 MV been achieved in the LER/HER cavities respectively, beyond the design values. During a high-current physics run in June this year 1.0/1.7 MV was achieved in the presence of beam currents of 1.35/0.8 A, currents that were not limited by the crab cavities themselves! Typical actual operating voltages for physics are now 0.8/1.3 MV. It is important to note that no single beam instabilities, attributable to the crab impedances, have been observed. The dampers work as predicted; the HOM + LOM power level is within specification taking into account for the LER the power absorbed by the external SiC damper, and the spectrum of beam-induced parasitic modes is as expected. The calibration of the crabbing voltage and phase using the beam has confirmed test bench measurements, though a closed orbit bump is needed to place the beam in the electrical centre of the cavity and minimize the power requirement.

With a world "first" that comprises sophisticated cavities never before seen in a machine, it is clear that there will be some issues to contend with initially. The most important, from the Committee's point of view, are as follows.

Trip rates: The changing trip rates of the LER and HER cavities can perhaps best be understood by following their operational history. The voltage capability of the LER cavity dropped during the first few months from 1.6 MV to 1.3 MV and then, following a particularly strong quench in March, went to 1.1 MV which is now the maximum value obtainable even after conditioning. This suggests that some damage has occurred to the surface of the cavity. A measurement of the unloaded cavity Q might lend some weight to this supposition, but this is a difficult measurement to do in the ring. Perhaps a method is to measure the Helium consumption at high cavity voltage. Eventually it will be necessary to remove the crab cavity from the ring to examine the surface and possibly re-treat it. For the present the cavity runs routinely at a lower voltage of 0.88 MV and trip rates are low. A voltage higher than the design value can still be achieved in the HER crab cavity. However the trip rate at the operational voltage has risen to 2-3 trips per day. Frequent short conditioning periods of the cavity and the coaxial line (the latter by displacing the line horizontally) have not improved the trip frequency, but the reason is not clear. It may be possible to improve the situation by a much longer conditioning period pushing the voltage at all frequencies within the range of the tuning system.

The turn around time following an abort is about one half hour so these trip rates, while annoying, are deemed acceptable in the short term. Pollution of the cavities from the "external" warm vacuum system must be minimized and in this context the installation of some trap, maybe superconducting, on either side of the cavities could be envisaged.

The tuning system. The excessive LER motor driven tuner backlash and the demise of the piezo-tuners leading to drifts of up to ± 15° in phase, is compensated to a large extent by the low-level beam control loops. This is not entirely satisfactory, especially with the possibility of the coupled beam instability (see below). We agree with the RF group wish to address and solve the problem of backlash and develop reliable piezo-tuners soon.

Coupled beams instability. With high currents in both beams a large oscillation in crab amplitude and phase at 540 Hz was observed. A model to explain this has been proposed involving coupling of the two crab RF systems by the beam-beam kick and the associated beam displacement at each crab cavity. In this case the observed frequency should depend on the low-level loop parameters. A cure has been found experimentally by shifting the crabbing phase and de-tuning the cavities. The resulting offsets in closed orbit beam position are corrected by bumps. This model should be confirmed by theoretical analysis, simulation and beam studies. This instability is important for other colliders wishing to use crab cavities.

Crab vacuum: LER cavity shows a high total pressure reading of ~7×10^{-6} Pa on the cold cathode gauge (CCG) near the coaxial line. This gauge is located at the entrance of a 500 l/s ion pump. A rough estimate of the gas load, neglecting the pumping through the annular space around the coaxial pipe is 3.5 10^{-3} Pa l/s. The residual gas composition from a mass spectrometer is consistent with an air leak. However, the committee has been informed that a localization of this leak from the outside of the system has been unsuccessful.

Under this assumption, the possibility can be investigated whether a significant quantity of air has remained trapped in a 'dead' volume inside the system. With the help of detailed drawings, at least one possible candidate could be identified. The closed-off volume could be at the bottom of an M8 tapped hole for the support structure of the coaxial line, which has no specific provision to be evacuated. There are three mounting bolts in each cavity. The combination of a stainless steel bolt in a soft copper block could be the equivalent of a leaky vacuum seal. Assuming a trapped volume of 3 ml initially filled with atmospheric air would amount to 3 10^{2} Pa l. The ratio of the two numbers provides an order of magnitude estimate for the time constant of the pump down ~ 10^{5} s. This time constant is quite long, but still short compared to the total time the LER crab cavity has been operated and thus may not be the primary reason for the observed vacuum degradation.

Recommendation: The search for the gas source should continue. The starting point should be a repetition of a global leak check of the cavity assembly followed by an in depth search of all subcomponents.

Recommendation: Independently, as an additional means to obtain information about gas trapped by the cold cavity surface, the integral gas load released during each warm-up to room temperature should be measured, e.g. it can reveal differences between LER and HER cavities.

4) BELLE Status

BELLE is the particle physics detector installed on the KEKB accelerator. The BELLE collaboration has about 400 members from 14 countries. This collaboration is very active.

The collaboration of the BELLE detector is very appreciative of all the data given them over the years by the KEKB team. This data has given rise to many physics analyses leading to many publications and discoveries. The recent measurement by BELLE of B → DTauNu was very challenging and a significant worldwide result. BELLE has also recently discovered several new exotic states which will expand the world's understanding of the B-meson system. They have also taken data on other Upsilon resonances namely the Y(5S). The BELLE collaboration may wish to run more on other resonances before the end date of March 2009.

Recommendation: The BELLE collaboration should work with the KEKB team to make a strategy to optimize the integrated luminosity between now and the end date of March 2009.

Recommendation: The BELLE collaboration should work with the KEKB team to develop plans, if any, to run on other Upsilon resonances before the end of the run in March 2009.

5) Knob Tuning Simulation and More Theories on Crab

In line with recommendations of the previous Review, extensive work has been carried out on simulation of the crab collision including the realistic modeling of the tuning procedure, and including various imperfections present in real beam-beam operation: transverse wakefield effects, noise of the orbit position, beam halo etc.

At present the achieved specific luminosity at bunch currents usually operated before, with crossing collision, is 1.5-2 times lower than the simulation prediction for perfect collision conditions. It is vitally important to prove that the presently used collision optimization procedures are efficient in raising the luminosity. In simulation, seriously detuned initial settings of Knob1 (12 parameters including the coupling parameters $R_{1\text{-}4}$, vertical dispersion, and its slope in both rings) resulted in a reduction of the luminosity by a factor 3. The parameters were iteratively scanned and corrected one-by-one to maximize the luminosity. The 3rd iteration already recovered the "design" luminosity.

This conclusion might be too optimistic, because i) during the first iteration cycle, the luminosity maxima vs scanned parameters were so flat that the measurement error (not represented in simulation) could easily fake the maximum position which at the very least would result in slowing down the convergence; ii) in reality the parameter set in each particular optimization is not complete, e.g. the Knob1 set does not include waist position, x-y coupling at the crab cavity, other parameters combined in Knob2 and Knob3, collision phase error, etc; and the incomplete parameter set has not yet been simulated; iii) it is not clear whether the degenerate action of certain knobs on luminosity can always be resolved; iv) some level of random change in parameters from hardware drift/instability will be present in the real machine.

It is important to continue the realistic tuning simulation with the feedback from the control room tuning procedures where the scans are sometimes limited to a narrow range due to beam lifetime limits, which means that the complicated profile of the luminosity maxima may be misinterpreted.

A considerable effort was invested in weak-strong simulation of the beam halo with the aim to explain the mysterious observation that with high bunch currents in collision, the (weaker) beam lifetime is asymmetrically dependent on the horizontal collision offset. Although the vertical beam halo was clearly dependent on the vertical size of the strong beam as well as the horizontal collision offset, the latter dependence was always symmetric in simulations. Further work is recommended on the weak-strong lifetime simulation including the machine nonlinearities; this could reveal asymmetries in the dynamic aperture vs horizontal collision offset.

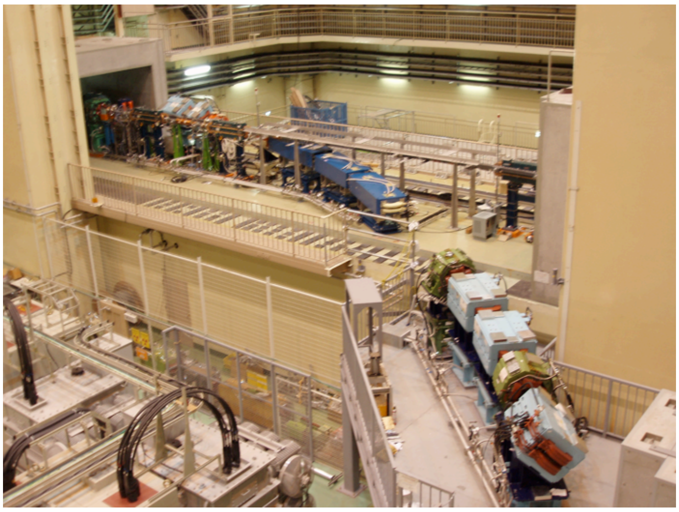
Effects of the wakefield on the crabbed bunch were also evaluated with the suspicion that additional bunch crabbing can appear or the effective vertical emittance may suffer from bending the longitudinal bunch axis in a head-tail type motion. From simulation, this effect does not appear to be serious for the KEKB parameters,.

Finally, the realistic evaluation of the Touschek lifetime with the dynamic aperture reduced by the beam-beam interaction is reportedly under way. This work is important because this effect can put a lower limit on the minimum vertical beam sizes at collision.

Recommendation: Continue efforts on realistic simulation of the luminosity tuning, optimization of the beam lifetime, simulating interplay of the machine imperfections, such as nonlinearities and noises, with the beam-beam effects.

Recommendation: Augment the simulation of luminosity optimization with additional parameter errors not included in the scans or simplex, realistic noise in measurement of luminosity or beam size, and some random change in parameters representing drift in machine conditions. Work with KEKB staff to determine limits for these effects that would prevent reaching an optimum tuning condition in machine operations.

6) Fuji Test Beam Line



The Fuji Test Beam Line (FTBL) was proposed to provide a GeV class test beam following the shutdown of the KEK 12 GeV PS. The facility is based on the use of bremsstrahlung photons created by scattering 8 GeV electrons off residual gas in the HER Fuji straight section. The photons are converted to e-/e+ pairs in a target creating electrons with a sharp forward peak, sufficient for a test beam of a few GeV/c.

The beamline was designed to re-utilize as many components as possible, in particular spare magnets from KEKB, recycled magnets from Tristan, and power supplies from the PS beamlines. However, a new, purpose-designed vacuum chamber was required. A peculiarity of the line is that the magnets are rolled up to 30° so the layout and magnet supports had to be designed carefully. Construction began in 2006 and was completed in September 2007.

The first test beam was observed on October 12th, soon after the KEKB operation started in October 2007. The FTBL magnet leakage field was observed to affect the KEKB operation so the leakage field shields were improved. The FTBL has started operation with test beams and FTBL commissioning will be continued.

The Committee congratulates the FTBL team for an extremely successful project. The Fuji Test Beam will be an important facility for developing new detectors.

7) KEK Roadmap and KEKB's future

The Director General of KEK presented the preliminary Roadmap for KEK. The boundary conditions to be considered included the end of construction of J-PARC, foreseen for 2009; continued operation of KEKB to produce an integrated luminosity of 1 ab^{-1}, also foreseen for 2009; and continued operation of the photon factory. Outside of KEK, results from the LHC and progress in the engineering phase of the ILC will affect the future of KEK. Starting from this scenario, it is proposed to continue J-PARC operations through 2020, including upgrades to the facility. Construction of SuperKEKB would begin as soon as KEKB has reached the luminosity goal with operation expected to begin around 2012. A compact ERL would be built in parallel to SuperKEKB as a test bed for a larger ERL light source.

This ambitious plan is now being presented to the government funding agencies and is therefore subject to change. The Committee strongly supports the proposed construction of the SuperKEKB and endorses the Director's plan.

8) BPM Displacement Monitors

Movement of the BPMs in sextupoles is a critical operational consideration. 100 μm errors can introduce significant coupling and optics distortion. Following on preliminary work done last year, many sextupole to BPM displacement monitors were installed in both rings during the summer shutdown, bringing the total number to 104 in the HER and 108 in the LER. In addition a few BPM displacement monitors have been installed to sample quad motion and beam duct motion relative to the floor.

The temperature coefficients of the position measurements, primarily caused by the linear coefficient of thermal expansion of the materials, were carefully studied. The largest was in the expansion of the target, which is heated more directly by beam current (10° C change). This introduces about 10 μm error from no beam to full beam current.

Data were collected from all position sensors during an initial filling of the rings. The shifts in position in the LER sextupoles followed an exponential-like approach to final values with an rms shift of 15-20 μm and a few transient motions of ~120 μm. The HER sextupoles exhibited a similar shift but of 20-25 μm rms plus an initial transient as large as 500 μm on several individual magnets. Corrections for temperature changes were not made. During continuous top-up filling operation the changes were generally less than 10 μm. The motions from initial filling were used in a SAD simulation to determine the effect on the optics. Following the magnitude of position changes, the HER showed generally larger changes in the optics parameters – $\beta^*_{H,V}$ changing by 3%, 4% respectively and coupling parameters changing by 1 to 6 tuning units. For the LER the β^*_V changed by 4% and coupling parameters by 0.2 to 2.7 tuning units.

The magnitude of these changes is expected to affect luminosity performance, though, to date, a clear correlation has not been established. Data from the position monitors are used to correct BPM data to the sextupole centers while recording orbits and performing global orbit feedback.

Comments: The Committee applauds the excellent work accomplished on the BPM displacement monitoring system. The data provided will be essential to controlling and optimizing machine tuning and optics.

The large transients seen in the HER during initial filling suggest a source of change in conditions observed after a beam abort where the transients may be significantly larger. Motions this violent may push hardware beyond elastic limits.

Recommendation: Information from the position monitors should be fully exploited to understand transient and long term effects, as well as in the routine correction of BPM data.

9) Tune/Orbit Measurements

The gated BPM technique developed at KEKB makes it possible to perform bunch-by-bunch position and oscillation measurement, which provides a lot of information important for multi-bunch operation. Bunch-by-bunch betatron tune measurements proved to be useful in previous electron cloud studies including the electron cloud wake measurement.

This time three different studies have been performed:

1) An attempt to get the horizontal bunch size from the profile of the coherent beam-beam kick measured as a function of the horizontal collision offset was done. The gated BPMs in both LER and HER are located at a betatron phase advance from the IP that is sensitive to the horizontal beam-beam kick while scanning the horizontal collision offset. Account has been taken of variation of the dynamic betas with the opposite bunch current. The measurements done with the crossing collision are compared with new ones taken in crab collision. While the former are in quantitative agreement with the expected size reduction at higher bunch currents, the latter indicate smaller sizes due to stronger beam-beam effect with the head-on collision and some quench in the profile curve at about 100 microns collision offset, if the

currents are high. This measurement may be interpreted as signature of the serious blowup of the horizontal bunch size caused by the collision separation by about 1 sigma. A correlation between the size reduction seen below this blowup and the nominal horizontal emittance (i.e., with the initial size) is also experimentally observed.

2) Bunch-by bunch gated betatron tune measurements during collision provide the response spectra with gated excitation under many different conditions. These spectra can be compared with the response of the pilot bunch as well as with data from an arbitrary bunch chosen within the train and missing the partner bunch in the opposite bunch train, i.e., with an ordinary bunch out of collision. While the full analysis of these data is complicated by the nonlinear nature of the beam-beam interaction, some features are already understood and the beam-beam parameter is evaluated from the measured spectra. The vertical tune shows an apparent saturation at low currents at a level of about 0.04, which is less than half the maximum attainable value as estimated from the luminosity. This discrepancy may signify complex current-dependent changes in the vertical tune spectrum, which are misinterpreted when using it for evaluating the vertical beam-beam tuneshift. On the other hand, the horizontal beam-beam parameter is measured up to about 0.1 and shows no saturation with currents. Some disagreement with the expected value is probably due to using a constant-emittance assumption in processing the measured data instead of the actual dynamic emittance. Many of the features of this technique, particularly, the dependence of the spectra on the excitation amplitude (no surprise in a highly nonlinear system) may be understood by systematic comparison of the measured spectra with those obtained in strong-strong simulation with adequate conditions.

Recommendation: Provide the full set of strong-strong collision simulation results relevant to the gated bunch spectra measurement in order to improve their interpretation. Consider the potential application of the gated tune measurement technique for the luminosity optimizations in operation.

3) Recently, bunch-by-bunch orbit displacements have been measured with the gated BPM. While the vertical displacements are not systematic with the bunch number and generally small (except for the LER bunch train head), the horizontal displacements show a clear trend from the bunch train head to tail amounting to about 110 microns in LER and 300 microns in HER, at the gated BPM position. The observed trend is in correlation with the 3 degree synchronous phase shift over the bunch train due to beam loading modulation of the RF resulting from the abort gap in the beam filling pattern. The systematic bunch-by-bunch horizontal orbit displacement may be caused by this systematic trend in the bunch arrival phase at the crab cavities resulting in the (linearly) different orbit kicks seen by the bunches. In terms of the IP orbit, the horizontal collision offset is estimated as the HER-to-LER difference of 40–19 = 21 microns at 1500/800 mA beam currents. As was shown, the detailed bunch-by-bunch signal has a correlation with the employed 3334… filling pattern, possibly coming from the wakefield signal. If the result is confirmed by further measurements of the bunch-by-bunch orbit displacements, the observed effect may become critical for raising the beam currents in collision. Presently, for better lifetime at collision with high bunch currents the HER bunch should be set at a 10-20 microns outward horizontal offset; this requirement cannot be met for all bunches in the train with the existing hardware.

Recommendation: Work on further clarification of the bunch-by-bunch orbit displacement effect and study its relevance to the luminosity limitation.

10) Wiggler, antechamber and collimator R&D

Chamber elements

A detailed update of the R&D work for the KEKB vacuum system was presented as a continuation of the work shown during the last Review. The production and first installation of several Cu beam ducts with antechamber design was completed during the summer. The new components represent a total length of about 30 m in the NIKKO wiggler section.

The vacuum chambers contain beam ducts for dipole and quadrupole magnets, bellows with comb-type RF shields and BPM units. Enlarged solenoids have been wound around the new drift chambers. Vertical steering magnets with larger aperture have been prepared and fit around the antechamber profile. The inner surface of the beam channel, exposed to the beam, has been coated with a 200 nm thick TiN layer to achieve a low secondary electron yield. After beam scrubbing it is expected to reach a δ_{max} value of 0.84. The coating is done at KEK with a dedicated system, which accommodates up to 4 m long vacuum pipes. Further design work will be necessary to optimize the beam duct shape for Super KEKB for impedance, coherent synchrotron radiation and deformation of the vacuum chamber due to heating.

A first attempt has been made to produce curved beam pipes as required for dipole magnets. Bending magnet vacuum chambers will contain a linear NEG pump assembly on the inner side of the antechamber to increase the pumping efficiency in the arcs. In view of the high thermal power load, it is proposed to replace the stainless steel end-flanges by special copper alloy flanges, to take advantage of the better thermal conductance. This should reduce the risk of leaks due to thermal gradients in case a flange is exposed asymmetrically to synchrotron radiation. This aspect may be particularly relevant for the arc chambers where synchrotron radiation preferentially strikes along the outer walls of the chamber.

From a vacuum point of view the new wiggler section has performed very well. The dynamic pressure graph presented to the Committee shows a decrease with beam dose consistent with expectation. The new comb-type bellows installed in the ring have performed without problem. The unfortunate fact that a vacuum leak appeared during this first running-in period, however, illustrates the increased importance of the vertical alignment of such wide vacuum chambers with respect to the synchrotron radiation fan. The Committee encourages the vacuum team to continue this development work and to install vacuum pipes with antechambers including the new RF bellows over a representative length of bending magnets, to study vacuum performance, mechanical movements and the need for any additional supports.

Movable mask

The ongoing R&D work for a movable mask was presented to the Committee. The previous version has been based on a copper coated head mounted on a Ti-coated Al_2O_3 support. During beam tests in LER, this model was destroyed due to evaporation of the copper coating and subsequent melting of the alumina head. The failure is attributed to several effects: the change of the dielectric coefficient with temperature, degraded heat conduction and a lower than assumed emission coefficient as the mask heats up. A new proposal was presented to the Committee, which aims to overcome the deficiencies of the old design. To improve the temperature capability of the head and to increase the heat conduction of the support post, it is proposed to make the support out of artificial diamond, which has more than twice the heat conductivity of copper. The temperature of the diamond head is limited to 1500°C; above this temperature graphitization occurs. At this moment, it remains to be shown that artificial diamond can be obtained in the required size and shape. The mask head for the new version will be made of graphite, which in principle is capable of withstanding temperatures of up to 3000°C. ANSYS calculations have been made to estimate the performance of this design and it is planned to validate the concept with a prototype mask when it becomes available.

The Committee acknowledges, that the mask remains a very challenging machine component in Super KEKB. The new mask version 6.1 is promising, but the Committee is concerned that weak elements of this design could be the joint between the graphite head and the diamond support, as well as the thermal contact between the support and the water cooled heat sink. These basic aspects should be validated independently before a prototype is constructed.

Clearing electrode test for dipole magnet chamber.

Clearing fields for removing electrons from an electron cloud have been proposed as a possible remedy for many high current machines. A solenoid field, which can be applied along magnet free sections does not work inside dipoles or quadrupoles. Depending on the beam parameters, a relatively weak field should be sufficient to extract the electrons along the magnetic field lines. The purpose of the proposed test system for the LER is to study the electric clearing mechanism and to confirm that the electron cloud can be locally suppressed. The proposal is to install a clearing electrode and an electron detector in a LER wiggler magnet. To obtain more detailed information about the cloud distribution, an array of 7 detector electrodes has been proposed. As compared to other experimental set-ups, e.g. the LHC test system at CERN, the bunch length in the LER is very short. Up to an estimated 150 W could be dissipated in the test chamber. The system is now under construction and planned for installation early next year.

Since the e-cloud effect is likely to remain a performance limitation for the LER also in the future, the proposed program is strongly supported by the Committee.

Appendix A

KEKB Accelerator Review Members

Andrew Hutton	JLab (Chairman)
Alexander Chao	SLAC
Warren Funk	JLab – unable to attend
Oswald Gröbner	CERN (retired)
Trevor Linnecar	CERN
Won Namkung	POSTECH
Flemming Pedersen	CERN – unable to attend
Eugene A. Perevedentsev	BINP, Novosibirsk
David Rice	Cornell
John Seeman	SLAC
Wang Shuhong	IHEP, Beijing – unable to attend
Katsunobu Oide	KEK Secretary, Accelerator
Shin-ichi Kurokawa	KEK Secretary, Accelerator