Committee Report on the BEPC-II Project Design Review

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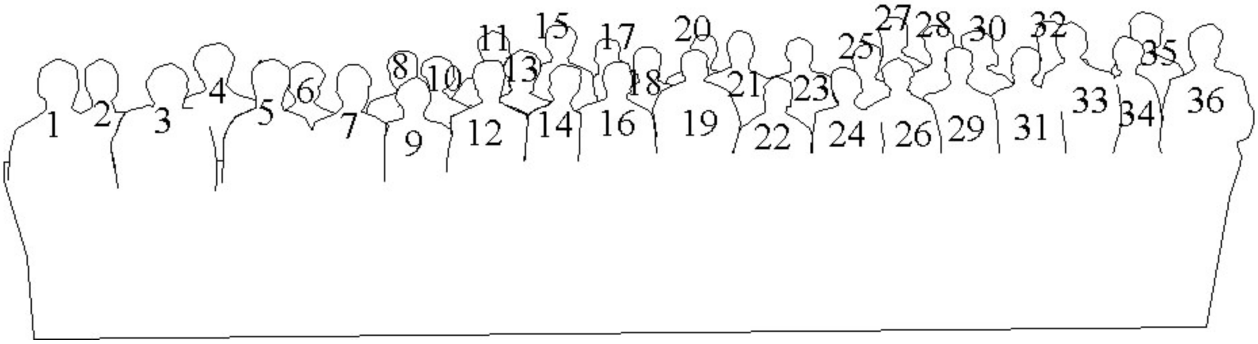
Committee Report

on the

BEPC-II Project Design Review

May 13-15, 2002, SLAC

BEPC-II Project Design Review Participants
SLAC, May 13, 2002



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Executive Summary

As part of the US-China Cooperative Program in High Energy Physics for the year 2002, a BEPC-II Upgrade Review meeting was held at SLAC, May 13-15, 2002. The upgrade is aimed at improving the luminosity and performance of the BEPC facility at IHEP in Beijing, China with major upgrades to the injector linac, storage ring, and detector. This review addresses mainly the accelerator related issues. Prior to the review, an updated Draft Design Report was made available to the review team. Most important technical change since April 2001 has been a change from a single-ring configuration to a double-ring. The goal of the review is to determine whether BEPC-II, if built as described, will meet the operations and physics goals. The charge to the review team is attached as Appendix A.

The meeting has been very useful with open and often detailed exchanges of information. The reviewers were impressed by the detailed studies already made on the two-ring BEPC-II Upgrade Design in the very short time available to the design team and enjoyed the open and up-front communications with their IHEP colleagues. Appendix B shows the meeting agenda. On the first day, the IHEP team made a series of presentations on the various BEPC-II systems, as shown in Appendix C.

Participants in the meeting included the BEPC-II team members and the review team members invited from Cornell University, SLAC, BNL, and LBNL who have been active in the electron-positron storage ring and factory colliders in the US. The list of participants is given in Appendix D.

The rest of this Committee Report consists of the technical reports from the four working groups. It will be clear from these reports that the reviewers think the design as is is feasible in terms of reaching the design energy and luminosity goals, and that no significant limitations have been found. The comments from the reviewers therefore focus on technical studies required to further optimize the design. The review team, however, wishes to point out that these studies, some already planned, should be carried out immediately so that their conclusions can be made in time to optimize the design without delaying the proposed schedule.

The review team has stated their recommendations for these studies in this Committee Report. There are four items among these studies that the Committee believes to be of more critical nature, and they are listed below:

(a) The vacuum chamber engineering design needs a close attention as soon as possible. The issues here include the screening of the antechamber against stray TE modes and proper separation of the distributed pumps from the beam. Depending on the conclusion of the study, the design may require a major redesign effort.

(b) The electron cloud instability is a potential threat to the BEPC-II performance, although the BEPC-II requirements will be more relaxed than those for PEP-II and

KEKB. Preventive cures of this instability need to be carefully evaluated so that their possible implementation is not prohibited by the current design.

(c) More attention must be given to the synchrotron radiation mode of operation. The present design has not given the necessary consideration to this mode of operation to assure its optimal use.

(d) The most critical and complex part of the BEPC-II lattice design by far is that in the interaction region. The present design, although adequate, needs more flexibility and a clear definition of operational diagnosis and correction schemes.

In addition to the technical issues, the review team also notes some areas of concern in terms of the project scheduling. Among the more outstanding on the critical path are the RF system, the vacuum chamber engineering design, the on-site testing of the superconducting magnets, and the need to identify the manpower resources to meet the schedule. The review team did not review the project cost.

Finally, the review team wishes to point out that international collaboration will be very critical to the success of the BEPC-II Upgrade project. In particular, the actual running experience with factory colliders at PEP-II and KEKB can be helpful. Help on the interaction region magnets and their compensations can be obtained through collaboration with BNL, while collaboration with KEKB would help the superconducting RF system. These collaborations must be maintained and, in the above areas, also enhanced as time progresses.

A. W. Chao and J. C. Sheppard
On behalf of the BEPC-II Review Committee

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Summary Report
Working Group 1: Parameters, Interaction Region

Alex Chao (SLAC, Coordinator), Stan Ecklund (SLAC),
Dave Rice (Cornell), Mike Sullivan (SLAC),
Brett Parker (BNL), John Seeman (SLAC)

Global issues

The IHEP group has made good progress in the BEPC-II lattice design. The overall design looks reasonable. The Committee hopes that the lattice can be made more flexible to allow for sufficient optics changes (such as tune changes, dispersion control in the interaction region and the RF section), and local and global coupling control. The optics should also be made more flexible for optimizing the synchrotron radiation operation.

A vacuum chamber must be designed with synchrotron radiation ports built in. This requirement may well complicate the design given that the synchrotron radiation mode and the colliding beam mode have beams in opposite directions.

In the present design, the nominal mode of operation requires dumping the remaining beam before each injection. It also suggests the possibility of a top-off mode in which the remaining beam is not dumped. The average luminosities in these two operational modes are 50% and 60% of the peak luminosity respectively. It is suggested that the top-off mode be adopted as the nominal mode to maximize the average luminosity.

It is suggested that, after adopting the top-off mode as the nominal operation, the mode of continuous injection (also called trickle charging) be studied as an option for BEPC-II to further improve the average luminosity. The issue involved is the possible increase of detector background during injection. In the present BEPC running, the detector background during injection is 10 times higher than during colliding beams. To address this issue, it is suggested that experiments be performed in BEPC on injection transport line collimators to control the background (even at the cost of lower injection rate). Furthermore, it is important that studies on possible continuous injection are done early on in the design stage so that this mode of operation is not prohibited by early design choices in the accelerator or detector.

The calculation of the luminosity of the BEPC-II collider should explicitly include the hourglass and crossing angle reduction effects. The peak luminosity given in the design report uses the simple traditional formula, and should be changed. The actual luminosity, taking into account these reduction effects, will be 15% lower.

The aluminum chambers will need to be TiN coated to prevent electron multipacting. SLAC mechanical engineering is willing to help with the design and testing of these coating techniques.

The components of BEPC-II vacuum chamber should be designed to sustain the heating power due to the maximum beam currents and luminosity envisioned for the BEPC-II. Possible later upgrades of the BEPC-II should be investigated so that early decisions do not forbid later upgrades which may require changes in power handling capabilities (of the photon stops, masks, bellows, etc), bunch numbers, bunch lengths, and β^*_y values. This extra design flexibility will pay off in optimizing the accelerator over the years.

Lattice

The BEPC-II layout poses special challenges for optics design, accommodating a 2-ring state-of-art high luminosity collider and a single ring synchrotron light source. Optimizing performance with an existing linac injector and machine enclosure is an additional challenge. The BEPC-II design team has produced a good design that seems to meet these requirements.

The arc optics provides zero dispersion at the interaction point and the RF cavities, a low β_{max}, and sufficient beam emittance. A missing magnet scheme aids obtaining a sufficiently large emittance and suppressing dispersion at IR and RF straight sections. The IR optics provide β^* values of 0.015 m and 1 m in vertical and horizontal planes and a ±11 mrad crossing angle to separate bunches spaced 2.4 m apart. Optics has been designed to meet minimum requirements for operation in the synchrotron radiation mode, but clearly there will be more development to optimize emittance, optic functions at insertion devices, etc. Individual control of every quadrupole provides the maximum flexibility in optics although the optics could benefit from additional flexibility.

Chromaticity correction is done with five families of sextupoles. Dynamic aperture is assessed by tracking with MAD for 2048 turns. Multipole errors used for dipoles, quadrupoles, and sextupoles are basically design values for these magnets. It was stated that the dynamic aperture is acceptable with errors as large as $7\text{x}10^{-4}$. (One question to be addressed is whether the momentum aperture of ±0.9% remains intact with these higher field errors.) This is a comfortable safety margin that should be maintained if possible. Tune ripple tolerance should also be included.

Orbit correction was demonstrated by simulation under nominal running conditions using several seeds for magnet misalignments. Residual rms orbit distortions of 0.55 mm (horizontal) and 0.15 mm (vertical) were typically achieved using half or less of the correctors. We note that the misalignments used in these models correspond to the survey goals which we felt were optimistic, perhaps by factors of ~2. Additionally orbit correction must be done after periods of operation without magnet realignment – typically resulting in additional misalignments by factors of 2-5. Furthermore, closed orbit bumps are often found to be very helpful in accelerator operation and the corrector strengths must be sufficient for both orbit correction and maintenance of closed orbit bumps. The stated strength of 0.05 T-m (~7.5 mrad at 2 GeV) is likely sufficient but this needs to be established. Failure modes of missing BPM and/or missing correctors should also be considered in this study.

The crossing angle parameter at the interaction point ($\theta \sigma_Z / \sigma^*_X$) for BEPC-II is slightly larger than that of KEKB, which has demonstrated good beam-beam performance. The options to reduce this parameter (by increasing β^*_X or ε_X) have the disadvantage of increasing beam aspect ratio at the IP with more challenging compensation of the solenoid field. We recommend preserving the maximum flexibility in options of collision point parameters to maximize luminosity. It would be advisable also to see if spaces can be reserved in case crab cavities are needed to remove the crossing angle problem, although it is not recommended to implement them initially.

Like all factory colliders, IR optics design requires much attention. Experience shows that the ease of operation of the collider depends often on the details of the IR design. Before collider construction, every effort should be made to continue to optimize the IR design and to improve its flexibility.

All colliders with solenoids in detectors have found realization of its effective compensation to be very challenging. The compensating solenoid configuration creates complex fields off the beam axis, adding elements to modeling of the beam optics. Extensive modeling and analysis of coupling errors and their detection and correction will help in the choices of configuration of instrumentation, corrector magnets, and commissioning plan. Magnet field errors, alignment errors, orbit separation schemes are part of this consideration because many of these issues are intertwined. Experience in existing factories suggests that instrumentation needs will likely to greatly exceed those anticipated in the design stage. Beam-based alignment corrections should be made to align the beams to the very tight tolerance needed for beam quality. Close cooperation with beam instrumentation and vacuum design groups will be needed. The IR optics work is one of the key items needing continued and further attention in the present BEPC-II design. We recommend this work be intensified as soon as possible.

We heard a minimal presentation of plans for operation in synchrotron radiation mode. There seem to be serious open questions that can affect design and operation, such as radiation damage to detector (is the solenoid on or off during synchrotron radiation operation?), parameters optimization at insertion devices, accommodation of x-ray exit ports, etc. A program to anticipate user needs would help focus design efforts.

Detector backgrounds

The effort that has gone into estimating detector backgrounds is impressive. The sources have been identified and traced to the IP.

Synchrotron radiation (SR)

The bending radiation fans are accounted for and heat loads on the beam pipe have been estimated. Masks to shield the inboard bellows and flanges need to be added. These masks may increase the local higher-order-mode (HOM) heating by generating small cavities and this requires some study.

The detector background from SR is primarily from quadrupole focusing in the Q1 magnets. SR from these magnets can directly hit the beryllium beam pipe. However, the photon critical energy is low (<1 keV) and the beryllium is coated with up to 20 microns of gold. These factors bring down the rate of photons penetrating the beam pipe to a value comparable to the PEP-II design. This corresponds to about 1 photon per beam crossing getting through the beam pipe.

Beam-gas and Coulomb scattering

Sources of beam-gas and Coulomb scattering from the beam have been thoroughly studied. Effort has gone into identifying where most of the backgrounds originate. Coordination between the background estimators and the vacuum group is needed to see if backgrounds can be further improved by more pumping and where the extra pumping should be installed.

With the present estimate of vacuum pressure, the energy deposition near the IR (±1 m around the IP) is again comparable to the values in the PEP-II. One potential caveat is that PEP-II has a lot of thick permanent magnet material around the IP that acts as a shield. BEPC-II will probably need to add a tungsten shield around the beam pipe under the cryostat that holds the superconducting magnets.

Also Touschek scattering should be included in the study of background induced by particle losses.

Detector response to background

The design team needs to continue with background studies and develop code that can simulate (at some level) the detector response to the machine backgrounds. In particular, all other factories have silicon detectors around the beam pipe and BEPC-II does not. This will change the backgrounds in the drift chamber since the silicon acts as a very good absorber of the low energy photons from SR.

Studies of backgrounds from the injected beam and from operation in the synchrotron radiation mode are needed to make sure the detector is protected from large radiation doses.

Collective Effects

IR higher-order-mode heating budget:

The IR, particularly the beryllium beam pipe near the IP, is sensitive to HOM heating from the two beams. The present design of the IR has large contributions of HOM heat loads, similar to PEP-II and KEKB. The present calculation estimates 1.4 kW of heat load from the Y-sections, and 0.7 kW from the tapered pipe transitions. The design team guessed that 1% of this heat load will propagate through the beryllium pipe. It is suggested the Y-section heat load be substantially minimized by a maximum allowed tapering.

The Y-section and the beryllium pipe HOM were calculated in separate MAFIA runs. It may happen that this calculation misses some modes trapped between the Y-section and the beryllium pipe and that more heating will result. Future work is needed to determine the amount of SiC absorber needed and its optimal location.

A HOM heat load budget should be reestablished with updated calculation and with tapered Y-sections. This budget should include the specifications of how much the HOM absorbers are needed, where are they located, and their cooling requirements. After the establishment of a new HOM heat load budget, it is to be compared with the proposed 100 W cooling capacity for the beryllium pipe. Liquid cooling may be necessary if powers over 100 W occur. In PEP-II 900 W is observed, but this may be due to nearby masking. See also the Appendix.

The present estimate includes a 1 W heat load in the Be pipe region due to trapped modes facilitated by the two synchrotron radiation masks at the two ends of the Be pipe. It also included a contribution of 17 W due to direct resistive wall heating of the Be pipe. These calculations need to be updated to include the gold coating being proposed for the Be pipe. The gold coating should help.

Given the difficulty of HOM calculations in a complicated geometry, there is some uncertainty in the results. It is best to be conservative in providing more cooling. The PEP-II sees more heat than originally calculated, of order 5 kW in absorbers near an abrupt Y-chamber. Beam conditions for BEPC and PEP-II are similar (Peak current x average current) so similar heating could occur.

It would be useful to make the HOM budget for bunch filling patterns in addition to that envisioned for nominal operation. A mandatory pattern is that for the synchrotron radiation mode, but other patterns should be included in addition in order to widen the operational flexibility of BEPC-II.

Impedance budget

A sound impedance budget was presented. The budget is made using the established method used for BEPC. The BEPC impedance Z/n was 4 Ohm, while that for the BEPC-II is estimated to be 0.2 Ohm. This large reduction was made possible because BEPC-II (a) does not require beam separators, (b) has 1 superconducting cavity instead of 4 room temperature cavities per ring, (c) has 2 kickers instead of 4 kickers, (d) has shielded bellows and shielded flanges. It is emphasized that this very low level of Z/n is recognized to be a difficult task, and every effort should be made to keep a good control of the impedance, including the establishing of an “impedance police” function with signature authority.

With a careful control of the impedance, due to the uncertainty in impedance estimate as well as the instability theory, it is advisable that a factor of 2 safety margin be kept at all stages of design before actual operation.

TE Waves through antechamber gap (See also Working Group 3 report)

Most of the wake fields produced by the beam are initially TM waves. However, some TE waves are generated when the vacuum chamber has a displaced geometry. These TE waves in an antechamber can propagate through the antechamber gap into the antechamber. This is not likely to be serious concern as far as heating the components in the antechamber is concerned, but will cause noise in BPM readings of up to 10's of microns. This issue and its effect on beam position monitoring should be studied.

Trapped modes by double masks

In order to operate both colliding beam and synchrotron radiation modes, part of the outer ring will have double masks around all flanges (and bellows unless they are of the retracted design). The design (size, geometry) of these masks needs to be performed with the need to minimize the possibility of trapped modes.

Electron Cloud Instability

Electron cloud instability is one critical issue for all e+e- factory colliders. BEPC-II's requirement on curing this instability is not as stringent as those facing PEP-II and KEKB, but is still substantial. The present design contains the measures of antechamber beam pipe and with TiN coating. These are expected to greatly suppress the ECI effect. BEPC-II simulations predict that with these measures, the electron cloud density will be substantially lower than the instability threshold.

The ECI study is being actively pursued by the accelerator community. The simulation tools for ECI are being updated and sharpened regularly and are now becoming trustworthy. It is suggested that simulations of ECI be repeated for BEPC-II using state-of-the-art simulation tools to make sure of the present conclusions.

With a reconfirmation that a combination of antechamber and TiN coating is sufficient to suppress the ECI, the present design should proceed. Installation of powerful feedback systems similar to those for PEP-II should provide further assurance of putting ECI under control. The additional possible cures for the ECI may then not be needed in the initial stage. In particular, there will be no need to install solenoids and/or clearing electrodes in the nominal design. It is suggested however that (a) the possibility of adding solenoids be kept as possible backup cure, (b) close attention be paid to the ECI research being carried out at other factories, (c) possibility of mini-trains be considered as another measure to reduce the ECI effects, and (d) BEPC experiments with photo-electron yield and clearing electrode be continued.

Beam separation during injection

Beam separation during injection is provided by varying the relative RF phase of the two beams. Beam dynamics during the process of bringing beams into collision will need more study to determine the required speed of the process, or if a higher value of β^* is needed. Experience in KEKB may serve as valuable input in this study.

An alternative is to inject the beams while they collide, as is done in PEP-II. In PEP-II, this is even necessary so that the beam-beam tune spread provides Landau damping to fight instabilities. This alternative should be studied also as an alternative for BEPC-II.

IR beam pipe appendix

The following note is from Mark Palmer at CESR/CLEO:

Date: Tue, 14 May 2002 15:04:52 -0400
From: Mark Palmer <palmer@mail.lns.cornell.edu>
To: David Rice <dhr1@cornell.edu>
Subject: Re: CLEO beam pipe cooling

The CLEO Be pipe is still cooled by PF200. The only problem that I am aware of is that PF200IG fluid is no longer in production. Andreas Warburton is still looking at replacements. There are 2 main issues with potential replacements (the most promising one is PF145HP): one is that they have lower flashpoints; the second is that they appear to be somewhat more aggressive solvents than PF200 (which we rigorously tested).
So there is some concern about O-ring life, etc if we use them.
If you want a detailed reference about the use of hydrocarbon coolants, you can refer to our paper (accepted for NIM A) which is available at:

hep-ex/0109015

ACTIVE COOLING CONTROL OF THE CLEO DETECTOR USING A HYDROCARBON COOLANT FARM
By A. Warburton (Cornell U., LNS), K. Arndt, C. Bebek, J. Cherwinka, D. Cinabro, J. Fast, B. Gittelman, Seung J. Lee, S. McGee, M.
Palmer, L.Perera, A. Smith, D. Tournear, C. Ward (Cornell U., LNS & Purdue U. & Wayne State U. & Minnesota U.). CLNS-01-1754, Sep 2001. 21pp.
e-Print Archive: hep-ex/0109015

Summary Report
Working Group 2: Injector

Stanley D. Ecklund (SLAC), Marc C. Ross (SLAC),
John C. Sheppard (SLAC, Coordinator)

Injector

We have appreciated the preparedness of the IHEP staff on the technical issues and for their candor. The communications with the staff were clear and open, leading to good understanding on both sides. This has greatly aided the understanding of the issues regarding the proposed linac upgrades. Much of the discussion centered about the need to increase the positron flux by nearly an order of magnitude above present operations. In addition, it is planned to increase the energy capability of the linac to permit on-energy injection of both electrons and positrons into their respective rings. The solutions presented to solving these problems should result in success if these solutions are properly implemented. It is likely that all of the solutions have been implemented in one form or another at various laboratories around the world; this should give confidence for a successful outcome. Several comments are listed below in regards to the upgrade plans for the linac for BEPC-II operation.

It is important to design the best possible systems prior to applying cost cutting measures. Much can be done in regards to values engineering once a need and solution has been identified.

Concern is expressed over the deterioration of the present performance of the systems in comparison to past performance. This trend is counter to most all operating accelerator systems in which performance is increased over time and not allowed to decay. This seems to indicate a lack of resources available for standard operation and calls to question if the resources can be made available to accomplish the upgrade tasks. It is noted that in the last 2 years, improvements have been made and the injector performance has increased. This certainly is a welcome development and helps to reduce the concern over available resources, which still remain scarce.

An increased effort in beamline modeling and accelerator physics studies is necessary to better understand present performance and to help in the understanding and development of future operations. There are a number of standard accelerator modeling codes available (Transport, TURTLE, MADD, LIAR) which can be used. The modeling required for the injector linac can be developed by a dedicated accelerator physicist with a strong interest in optics. It is recommended that a full time staff member be assigned to this injector modeling work. (It is noted that the optics for electron and positron beams for BEPCII-Linac have been designed with TRANSPORT-code and the beam modeling has also been done using the LIAR-code, as described in the BEPCII Injector Linac Design Report (p.371-382).)

It is important to understand beam loss in the transport lines downstream of the linac. Is the acceptance of the transport line really smaller than the linac? It is useful to determine why the apparent electron spot size of the positron target cannot be made smaller in the present system. These are issues which are modeled in a straightforward manner. Such studies may point the way to beamline modifications which can and must be addressed during the upgrade.

The minimal amount of beam instrumentation in the present system is of concern. The importance of instrumentation to ensure day-to-day, month-to-month reproducible operations must be emphasized. One must be able to fully characterize the beams at the injection point to determine if potential problems with injection are due to poor beam quality or due to inadequate ring acceptances. In addition, distributed instrumentation allows for ease of operations, setup, and diagnosis of problems. The types of instrumentation required include beam position monitors, transverse beam profile monitors, beam current monitors and beam loss monitoring.

There will be issues associated with the large differences in the electron and positron diagnostic signals. Those that work for positrons are likely to saturate with electrons. Effort must be taken to ensure adequate diagnostics for both beams. Other laboratories have faced similar issues (LEP LIL, APS, KEKB) and their solutions to these problems may be able to provide guidance.

In addition, increased RF diagnostics and control are required; the proposed RF phasing system and phase reference line is an excellent idea. The proposed RF phasing system appears to be based in large part on the KEKB linac phasing system. Close collaboration with the KEKB staff is encouraged. At SLAC, there has not been very good experience with beam induced phasing signal generated from short pulse beams. Caution is advised against relying on such systems.

Two issues come to mind in regards to the proposed ring upgrades which will affect performance and design requirements. First, the specified energy acceptance of ±0.5% seems unusually tight. This is a difficult specification to meet in regards to positron production. A relaxation of the tolerance would be helpful. (It is noted that at present, the ring energy acceptance is ±0.8% for 1.33 GeV injection; increasing injection energy to 1.89 GeV reduces the relative energy spread to ±0.5%. It is still useful to increase the ring relative energy acceptance.) It is strongly suggested that the choice of ring RF frequency be revisited in consideration of the issues of timing system requirements. Significant simplification and ease of operation is expected if the ring RF frequency is a subharmonic of the 2856 MHz linac RF frequency. In addition, it is important that the timing system requirements for the linac are well understood and discussed with the timing system developers. The timing requirements for the pulsed linac systems are very different than the rings which operate in a quasi-steady state mode.

The design report discusses an upgraded cathode and a higher voltage gun to meet the increased electron current requirement. The higher voltage can be achieved through straightforward design methodologies. Consideration should be given to using pulsed high voltage instead of simply dc high voltage, particularly at the upper end of the voltage range under investigation.

Other techniques to meet the increased electron peak current requirements include subharmonic bunching and utilization of RF gun technology. An RF gun system to replace the existing dc gun and bunching system consists of well developed technologies and are expected to meet the linac beam requirements. One note of caution is that while the RF gun is rather straightforward and potentially maintenance free, the laser systems can be problematic. Lasers typically require significant adjustment and maintenance. Considerable effort is necessary to develop a turnkey laser system; this effort is straightforward, consisting of developing engineering solutions to each problem as they arise until the problems either go away or become manageable. Whereas these techniques are not being considered in the present planning, they are noted as technologies which presently exist should difficulties arise in the more straightforward approach of higher gun voltage.

In regards to the linac power systems, several comments are in order. It would be better in the long run for maintenance and spares inventory if only a single type of klystron is used. This applies both to the klystron inventory as well as to the modulators. Recent developments in the area of solid state modulators may be applicable to the BEPC-II requirements.

As far as high gradient, gradients in the range of 25 MeV/m should not be much of an issue for a clean, high vacuum situation. Demounting, cleaning, and baking of existing accelerator sections should be considered.

The causes of the RF coupler window breakages are not understood. These are devices that can be purchased at modest cost, however.

Consideration should also be given to purchasing KEK/Matsumoto style high power loads. These appear to work very well and look to be much simpler than the old style Kanthal loads. Consultation with KEK should be made.

Much of the linac upgrade discussion centered on the need to increase the positron production rate by a factor of about 10. The issues of increasing repetition rate, primary electron beam energy, and primary electron beam current are all straightforward and can be expected to give the anticipated results.

Increase of the capture efficiency can be more difficult. Fixing of the downstream solenoids along with the addition of a pulsed flux concentrator should all help. Consideration of reducing the incident electron beam size on target is expected to help also.

If the acceptance of the downstream linac is increased, this must be accompanied by a similar increase in the acceptance of the downstream transport line which presently exhibits beam loss. Studies are needed to address this issue.

The suggestion of two-bunch acceleration should be fully explored. The SLC at SLAC operated in this fashion for many years and should not be a problem for BEPC-II, but studies of both the linac operation and ring injection for 2 bunches need to be conducted. Consideration of additional instrumentation, feedbacks, and operations plan should be included in these two-bunch studies.

Several recent positron systems (Frascati, CERN CLIC e+ source) have been designed wherein the positrons are initially decelerated in the capture process to produce higher positron yields. This should be looked at for BEPC-II.

General Concerns

The following is a list of additional general concerns that arose in our discussions of the linac, source and beam instrumentation. Some of these concerns have been previously mentioned above.

Injection rates and injection control
The present BEPC e+ injection rate is limited to 4 mA/min with 10 pC at 12 Hz. The goal is to increase the injection rate by a factor of 10. Present transport line and ring capture efficiencies are 60% and 80% respectively. It is assumed that these will not be improved, but will instead be better understood with the addition of diagnostics. The improvement in fill rate is expected to come from a combination of the increased repetition rate (50 Hz) and increased e+ intensity (40 pC). The present electron fill rate is up to 50 mA/min. BEPC-II electron linac intensity will be 0.5 A for 1 ns (~10 times the positron intensity). Two-bunch injection will be developed following the commissioning of the one-bunch system. The tolerances for the two-bunch system are somewhat tighter.

What is the tolerance on the bunch-to-bunch intensity difference? There should be a system for the control of the bunch intensity. This needs to be added to the timing system specification. Filling time is estimated as follows: t_f = 910/50(e+ rate)+910/200 (e-rate) +0.05= 0.43 hrs .

Structure replacement
All structures through the positron system will be replaced. This amounts to 8 structures. The structures appear badly damaged when examined through the input coupler. The structures are limited to 10 MeV/m because of outgassing of the load following installation in 1986 – due to lack of bake. The same machine shop produced the structures for PLS and these are operating at 18 MeV/m – the same process will be used for the new structures. The loads will be more aggressively baked before installation in order to prevent a repeat of the problem. We suggested using SiC loads but these are harder for IHEP to fabricate. IHEP should consider purchasing the loads instead of fabricating them in-house. The downstream structures are operated at 15 MeV/m.

Positron target beam size

How can the beam spot on target be kept minimum for the large energy spread beam? Positron target beam energy spread may be larger due to beam loading associated with higher intensity beam; this is mitigated by the higher beam energy on target.

Stability tolerances

SLED PSK trigger jitter tolerance should be much less since there is only one PSK – for two-bunch operation. The water tolerance should be listed for the SLED temp- which is 0.1 not 0.3 deg C. High Voltage power supply should be 1% stable. The tolerances for two-bunch operation should be tabulated.

Broken Bethe-hole coupler windows

There is a history of broken directional coupler windows at IHEP. Testing is required in order to prove new coupler designs, for example, new ceramics and new coatings. The use of the ATF style couplers should be investigated.

Software for the control of the Modulator/Klystron interlocks.

There should be some protection. LabView is designed to be very flexible; this flexibility can be problematic due to software errors and software limits over-writes. Crucial hardware systems may need hardware interlock protection.

Positron profile monitor dynamic range

At present, the positron beam cannot be seen on the profile monitor screens. The beam size is too large for the screen and the intensity (10 pC) too small to see. The limit of the screen (sensitivity) is 10pC (1e-11/1.6e-19 = 0.5e-8 e+). A more sensitive screen material should be investigated.

Beam position monitor dynamic range

What is the sensitivity of the log-ratio BPM? Is the Bergoz system sensitivity adequate? Make BPM's for the BEPC2 linac – 120mm long and 60 degrees azimuth coverage per strip. This is about 4 times the SLAC linac stripline coverage – the SLAC BPM system would then be sensitive to 20pC.

Summary Report
Working Group 3: Instrumentation and Control, Radio Frequency and Feedback Systems

Sergey Belomestnykh (Cornell), John Corlett (LBNL),
Bob Hettel (SLAC), Rusty Humphrey (SLAC, Coordinator)

Superconducting RF System

Findings

System design is appropriately conservative. The Committee sees no fundamental problems.

There is no superconducting RF or cryogenic system experience at IHEP. IHEP is collaborating with KEK; also with Harbin University for cryogenic system design.

Collaboration with KEK: 2 IHEP people have already been at KEK for a year as part of the design effort. 3 more will be sent for 0.5 year each to learn and participate in HOM and other measurements.

RF Cavities: The schedule is for Mitsubishi to build the cavities over a 1.5-2 year period. IHEP will develop the specifications collaboratively with KEK.

Comments

RF Schedule: The schedule is to have the first cavity delivered in time for lab testing 1/2004, with the second cavity arriving in time for system testing 5/2004. This is a very aggressive schedule.

Superconducting RF Klystrons: Why not use IOTs instead of klystrons? Because IHEP decided to use the same klystron as the Shanghai Light Source, thereby gaining the benefits of a collaboration.

RF Cavities – Schedule: A high-level schedule exists. But a detailed schedule needs to be developed in concert with KEK.

RF Cavities – Higher Order Modes: Re-do the calculation of HOMs with the actual cavity and taper geometry.

Cryogenic System: The cryosystem loads should be better defined; e.g., the waveguide cooling requirements.

Cultural Noise: How does the existing infrastructure affect the spectrum of cultural noise? Superconducting RF systems are notoriously sensitive to microphonics. A survey of the existing sources of cultural noise should be made. It was noted that the Q for this system is "only" of order 10^5, so this is less of an issue than at other installations where the Q is of order 10^7.

Cultural Fields: It was pointed out that iron rebar in concrete can become magnetized, and create magnetic fields which will affect the superconducting RF. A survey of existing sources of magnetic field should also be made.

Recommendations

The schedule looks too tight to the review team. Specifically, the test date of 1/2004 is too close, and, in the opinion of the review team, cannot be met.

Collaboration with KEK: Some mechanism for weekly or monthly collaboration meetings with KEK should be developed. Video conferencing is a possibility. The relationship with KEK is critical, and progress needs to be actively monitored.

Control System

Findings

EPICS: The decision to use EPICS as the basis for the BEPC-II control system follows the direction set by many accelerators in the world. The fact that KEKB also uses EPICS will provide critical resources to IHEP.

Timing System: Design is very preliminary. Clearly needs more work. The integration of the timing system into EPICS needs to be addressed carefully. The use of EPICS for synchronous data acquisition and control at 50 Hz is not all that common, and some care must be taken to ensure that it performs adequately. The timing system requirements for the linac also need to be developed and taken into account for the system design.

Front End: There are many devices, with varying interface requirements, for BEPC-II. There appears to be adequate resources allocated to the development of EPICS drivers and VXworks support. The effort here needs to be carefully managed, since the use of Chinese manufacturers for front end equipment will probably mean that some EPICS drivers do not exist, and thus will have to be developed by IHEP.

Manpower: The project team for BEPC is 15 people for 4 years. This does not include students, who are a rich source of creativity and effort. This is probably adequate, but requires that the strategy of porting applications from other laboratories must work. Minor comment – there needs to be a network manager as part of this team.

Comments

EPICS: The change from the BEPC control system to EPICS for BEPC-II requires that applications from other laboratories be transported to the BEPC-II control system. The impact of this strategy is that the applications programming effort needed for BEPC-II is estimated at only 12 person-years (2 SW engineers and 2 accelerator physicists for 3 years). However, if this strategy is not successful, then it will be necessary to rewrite the BEPC applications in the EPICS environment. An estimate of this effort from the BEPC team is that it would take 80 person-years of SW engineering.

Power Supply DAC resolution: IHEP should reconsider the DAC resolution; i.e., 18 DAC needed for 16 ENOB (Equivalent Number Of Bits). The suggestion is that 16 bit DACs be used for small supplies, and 18 bit DACS for large supplies.

Recommendations

Applications Programming: The BEPC-II project should monitor closely how successful the transport of applications from other labs to the BEPC EPICS system progresses. As noted above, this strategy is critical to the SW resource estimate.

Instrumentation

Findings

Linac Positron Beam Profile Monitors: Screens are the right technology, since screens should be more sensitive than wire scanners. The experts on the review team note that seeing less than 10 pico-coulombs on a screen is difficult without constructing the screen from a special material or using a more sensitive camera. The requirement for BEPC-II positrons is sensitivity from 3 to 40 pico-coulombs.

Storage Ring Scrapers: There aren’t any in the BEPC-II design. This is a conscious decision; the BEPC experience is that they were not useful. One member of the review team notes that they are very useful in the commissioning process for studying lifetimes.

Beam Dump Mechanism: How is IHEP planning to dump the beam in BEPC-II? The review team does not believe that the experiment will be happy with just turning off the RF and allowing the beam to scrape off on the vacuum chamber.

Beam Loss Monitor System: No design yet exists.

Comments

BPMs: The electronics system design for Beam Position Monitors seems adequate. However, the review team suggests that the BEPC BPM team should consult with other laboratories about experience with logarithmic front ends, since this approach is not all that common, and some problems have been reported at Fermilab.

Bunch Current Monitor and Automatic Bunch Injection: The BEPC-II design for the Bunch Current Monitor System includes the capability of automatic injection for top-off mode. This system – and other associated systems – should include the flexibility to provide many different fill patterns for BEPC-II.

Storage Ring Profile Monitors: Are eight insertable screens really needed in the storage rings? Much of the first-turn requirements can be met by the BPM system. Insertable screens increase the impedance, etc.

BPM cabling: Consider the use of LMR400 instead of RG223 cable.

BPM calibration: Consider the use of beam-based calibration and quadrupole modulation to characterize BPMs instead of wire mapping in the lab.

Storage Ring Synchrotron Radiation Monitor: Consider the use of Glidcop as a material.

Recommendations

BPMs: PEP-II, ALS, and APS have all encountered problems with the effect of propagating TE modes on BPMs in large vacuum chambers. It is the opinion of the review team that the BEPC-II positron vacuum chamber, with its antechamber, has the same problem. IHEP should study this design, to confirm whether or not the problem exists. If it does, the vacuum chamber should probably be redesigned.

BPM Buttons: IHEP should use the proprietary, but commercially available button design used at PEP-II and KEKB. In-house design and fabrication will be difficult.

RF Feedback – Longitudinal and Transverse

Findings

The system proposals for both longitudinal and transverse feedback systems are adequate. The longitudinal system proposal is to use the SLAC PEP-II digital system. The transverse system proposal is to use the ALS analog system.

Comments

The review team notes that both of these systems require significant resources for support. It suggests that a dedicated team of 3 people for 3 years is necessary – with access to electronic and mechanical engineering support.

The Trieste Light Source – Elettra – has recently implemented a longitudinal feedback system with similar specifications to the PEP-II system. This system utilizes all commercially available modules, and IHEP should investigate this as an alternative.

The location of pickups for the transverse feedback system must be capable of operation in both collider and synchrotron radiation operation modes; that is, the lattice must have $\pi/4$ phase advance between the pickups.

The growth rates for different bunch filling patterns should be calculated.

Using digital signal processing in implementing the delays and filters for the transverse feedback system might offer more flexibility in system configuration than an analog system, and would allow powerful diagnostics of coupled bunch motion and growth rates.

Recommendations

Locked RF Systems: IHEP should consider the benefits of locking the RF systems of the gun, linac, and rings to reduce injection transients in the longitudinal feedback system.

Summary Report
Working Group 4: Magnet, Vacuum, Power Supply and Mechanical Systems

Paul Bellomo (SLAC), Scott DeBarger (SLAC), Linxiang Jia (BNL),
Lowell Klaisner (SLAC, Coordinator), Brett Parker (BNL), Jack Tanabe (SLAC)

Magnets

The specifications and requirements for the ring magnets are not unusual and are well within the range of present design practices and technology. The designs described in the oral presentations and given in more detail in the written documentation will satisfy the requirements.

The magnets and the environment near the interaction region present a more challenging (but solvable) problem. Although the impact of the detector solenoid leakage field in the region of the septum magnet separating the electron and positron beams is not clear, it is generally believed (and has been stated in the meetings) that it is desirable to reduce this field. This field can be reduced by two means. First, experiments can be performed at lower solenoidal fields, which will also enhance the accelerator performance. This reduction will reduce the fringe field. Calculations should be made to evaluate the improvement in the fringe field due to reduced solenoidal field so that this option can be evaluated. Second, the effectiveness soft iron shields in the conical region of the end cap, coupled with reducing the reluctance of the solenoid iron circuit, should be investigated.

While high level design requirements exist that are met for the main quadrupole, dipole and corrector superconducting magnets design presented, greater attention needs to be given to the anti-solenoid/shield solenoid magnets. For instance a decision whether the anti-solenoid and shield solenoids can be powered in series awaits development of an operational scenario for their use, combined with the skew-quadrupole, for decoupling the beams. Note that the design of the anti-solenoid/shield solenoid is strongly influenced by the design of the BES-III detector solenoid and requires close interaction with the detector group when the fringe field reduction study discussed above is performed.

Another area where care needs to be taken to ensure that operational requirements are consistent with the superconducting magnet design is in determining ramp rate requirements for the superconducting coils. Here we note that too rapid ramping of a superconducting magnet can induce persistent current multipoles that impact field quality in a time-dependent manner. This should be kept in mind if the SCB horizontal bending dipole were to be used in an automatic feedback orbit control circuit.

The design of the first septum magnet shield may need changing in order to reduce the fringe field leakage into the field free path of the adjacent beam. In addition, the shield geometry may be made nearly symmetrical to the septum yoke geometry (similar to the PEP-II Q2 final focus quadrupole) in order to balance the shielding effects of the yoke and the shield on the solenoidal field for both the electron and positron beams.

In the oral presentation, it was reported that the 2D field optimization of the first septum quadrupole did not meet the required multipole limits and that the end chamfer will be used to provide a 3D fringe field region which will compensate for the 2D error so that the field integral will satisfy the physics requirements for this magnet. A further attempt to improve the 2D field may be attempted by judicious adjustment of one or two conductors near the beam aperture.

There was some discussion of the fast injection kicker and the difficulty of satisfying the needs to simultaneously reduce the resistance to image currents while concurrently minimizing the eddy current attenuation resulting in loss of uniformity of the magnetic field. The kicker pulse width was described as a half sine wave, approximately 600 ns long. The ferrite core kicker design with a ceramic chamber, coated and striped for eddy currents, was eliminated from consideration because of the larger stored energy and the difficulty of powering this magnet. However, there was some interest in the ALS kicker design, which uses a 1.2 μs half sine wave. The ALS kicker takes advantage of the fractional tune of the lattice. It is recommended that this option be investigated. A wider pulse length can simultaneously simplify the design and power supply requirements of the air core magnet and its image current resistive coating while at the same time expanding the design options to include a ferrite core kicker option.

Vacuum and Mechanical Systems

The fit of the positron ring vacuum chambers with the beamline magnets is very tight (3 – 5 mm). Careful attention to the outer dimensions of the vacuum chambers will be required during fabrication to permit alignment of the magnets on girders with the vacuum chamber in place.

The details of ports for synchrotron light beamlines were not presented. The current design of the photon absorbers has a maximum temperature rise in the cooling water of 46°C. For a more conservative design, the flow of cooling water within the photon absorber could be increased in order to reduce this temperature rise.

The supports of the vacuum chambers and beamline components in the Interaction Region pose special challenges during installation and during operation. Installation will require special attention to procedures and the sequencing of tasks. Support of gravity, magnetic, and vacuum loads during normal operation will also require careful review.

At least some of the ion pumps in each ring of BEPC-II will need to be stabilized for pumping argon.

The planned vacuum processing techniques described to the reviewers, with chemical cleaning followed by bakeout (at 140°C for aluminum, 200°C for stainless steel) of all vacuum components, are appropriate for the BEPC-II application.

Micron-sized dust in the vacuum chamber can be drawn into the electron beam and cause lifetime and background problems. Care must be taken to insure that small particles are cleaned out of the vacuum chambers and not allowed back in through processing or installation. Also, care needs to be taken in mounting NEG pumps to insure that small particles of NEG material can not get into the beam channel. Vacuum chambers that have NEG pumps should be vented slowly to avoid moving dust into the beam channel.

TM modes in the vacuum pipe can be converted to TE modes by features on the vacuum wall. These TE modes can propagate through slots in the vacuum system and couple energy from the beam to vacuum components located behind the slots. For example, this can result in heating of the distributed ion pumps. Also, this is an issue for the bellows modules. Energy can propagate through the slots between the fingers and heat the bellows convolutions.

In the PEP-II design, the beam sees longitudinal slots for minimum impedance. In many cases, the bars between the slots were pressed inward to keep constant impedance. These slots always have a screen behind them to prevent coupling of energy through the slots. In the case of the High Energy Ring arc chambers, the screens were formed by an array of holes. In discrete pumping ports, the slots have screens welded behind the slots.

In PEP-II, the design of the holes behind the slots for the HER Distributed Ion Pumps were set at an angle to prevent a direct path for synchrotron light from the beam to the DIP plates. Also, this arrangement reduced the probability that particles generated at the plates by discharges could propagate into the beam channel.

PEP-II has had problems with heating of the convolutions of some of the bellows modules. These are now being cooled with local fans.

The BEPC-II slot designs, as shown on page 151 of the Draft Design Report, should be changed to include screens to prevent propagation of energy from the beam channel to the volume behind the slots. This is an issue that must be considered as soon as possible so as not to delay the present fabrication schedule.

The design of the positron ring vacuum chamber includes an antechamber that widens the aperture and reduces the electromagnetic wave propagation cut-off frequency. In addition to the effects of the transverse vacuum chamber dimension, the narrow slot through which the synchrotron radiation passes to reach the antechamber acts to further reduce the cut-off frequency of radiofrequency modes in the structure (similar to a double-ridged waveguide). Our concern is that TE modes generated by the positron beam will couple to the BPMs, producing a beam-intensity and beam-position dependent signal in the vertical (predominantly) BPM processing electronics, which will result in a position error on the BPM.

The Committee recommends that the vacuum chamber design be modified to ensure that the TE mode is not propagating at the BPM detection frequency in the sections containing BPMs. The antechamber may be reduced in width to provide a TE mode cut-off above the BPM operating frequency of 500 MHz. Another solution, to reduce the BPM operating frequency (to 250 MHz), reduces sensitivity of the buttons and makes bunch-by-bunch measurements impossible when all buckets are filled.

Power Supplies

In general, the power supply concepts that were presented are excellent. There do not appear to be any technical showstoppers. However, there are some issues that should be addressed to ensure that the power supplies can be built within the allotted time schedule and to improve system performance, function or reliability.

The IHEP power supply group consists of 10 persons. It is envisaged that, in the future it will also consist of a maximum of 10 persons. The exact makeup of the group members is unknown and no increase in group size was mentioned. However, it has been mentioned that this group will be responsible for the development, design, prototyping, prototyping testing, fabrication, testing and commissioning of some 340 diverse power supplies ranging in output from watts to several hundred kilowatts. This group will also participate in the development of a new, hybrid analog/digital power supply controller. These tasks will be interspersed with those tasks needed to maintain the present BEPC and keep it running in good order. This 10-member group might prove to be insufficient in number to do all of the assigned tasks. It is the Committee’s recommendation that power performance specifications be defined as quickly as possible with the intent of pursuing or considering the purchase of standard products from industry or having industry “build to print”. The SLAC Power Conversion Department would also be very interested and happy to assist. The assistance might entail the design of some of the more special, esoteric or difficult power supply designs or the less involved role of providing consulting services.

Because of space limitations, IHEP is proposing to water cool any power supply with an output rating > 3 kW. According to the IHEP design summary, this will entail water-cooling approximately 220 power supplies. SLAC experience is that water systems cause trouble, and the trouble increases with time. SLAC typically uses water-cooling when the output rating of the power supply exceeds 100 kW or in unusual circumstances. The potential cooling water problems might be deleterious to power supply reliability and availability. The space issue should be pursued further before making a final decision to water-cool so many power supplies.

Inner and outer ring Bend Power Supplies will use conventional 12 pulse rectifiers, each fed from 2 transformers with extended delta primaries for the required 30^{O} phase shift. The secondary of each transformer is configured in wye and connected to center-tapped freewheeling diodes to effectively reduce the input line voltage by 1/1.73 at low output current during ramping, standardizing or other operations. This has the effect of correspondingly reducing the retard of the SCR gate triggers. The result yields a higher power factor, lower harmonic distortion of the line voltage, lower line noise and lower output voltage ripple at low output currents.

The Bend Power Supplies employ a critically damped second-order Praeg filter. The design that was presented has the correct response and component values. Because of power supply and/or money limitations, there will be two independent magnet strings for the inner and outer rings. There was no mention of any ties between the two strings to ensure current tracking. However, the resolution, accuracy and tracking of the power supplies have been specified to within 30 ppm of the output current. The absolute accuracy of a good zero flux current transductor is an order of magnitude better. The independent string approach has been successfully employed on the PEP-II high and low energy bend strings. For this reason, SLAC believes that the two-independent-string-system will current track quite well.

The bend power supplies will be thyristor based and 100 ppm stability over 24 hours has been specified. In order to achieve this stability the current loop will employ high stability zero flux transductors commercially manufactured or built in-house. Although the 100 ppm is achievable with an SCR power supply, better stability, regulation, bandwidth and transient response can be obtained if the SCR power supplies were used as voltage sources followed by switch-mode chopper regulators.

IHEP would like all power supplies to have output current control from 0% to 100% of power supply output rating. However, a zero voltage switched (ZVS) resonant power supply is specified for the Septum and several superconducting magnet power supplies. This should be looked at since ZVS power supplies current regulate by varying the modulation frequency and usually cannot provide control down to 0%. Furthermore, it is not clear why a resonant mode converter, with its added complexity, is needed in this application. Because of the low voltage, high current output, in order to reduce the output rectifier voltage drop, IHEP has correctly opted to use a 2-pulse rectifier with a single diode voltage drop in each rectified output pulse. As another alternative, IHEP might consider the use of relatively new synchronous rectification using low-voltage drop switched IGBTs. Some of these power supplies will have output currents rated > 500 A. In order to achieve these ratings IHEP will parallel output rectifier modules with no active current sharing capability. The Committee feels that the depicted scheme will work, but careful matching of components from module to module might be necessary to assure reasonable, if not perfect, current sharing.

Quadrupole and sextuple power supplies will be buck regulator choppers fed from unregulated SCR voltage sources. The choppers will have conventional voltage and current feedback loops. There will also be a voltage feed-forward loop, ostensibly to account for voltage dips that will occur as chopper power supplies are turned on and off. The concept appears sound.

For the trim magnet bipolar current source power supplies, the H-bridge scheme switching in the 50-50 mode (and there are at least two 50-50 schemes) appears to be a very acceptable choice and this topology was used in BEPC. Regardless, one switching scheme is efficient; the other one is not efficient. In the efficient scheme both bridges are always active, one pair of diagonal transistors in the bridge form the (+) output leg and the other diagonal pair form the (-) output leg. The 2 transistors in each leg are 180^{O} phase shifted from each other. And the 2 legs are complementary phase shifted. The output frequency from this scheme is twice the individual transistor switching frequency. A high-frequency front-end switching voltage source is used to reduce the size of the transformer that matches the line voltage to the load voltage. It is a half-bridge converter that uses a combination of capacitors and solid-state devices. Capacitors are physically much larger and have low mean time between failure (MTBF) ratings. A better choice might be to replace the capacitors and use an all solid-state full bridge converter.

It has been mentioned that building space is limited and cables are installed underground or in the floors. Underground installations are costly and do not lend themselves to future expansion or revision. It might be prudent for IHEP to consider installation flexibility by adding space-saving overhead cable trays for power supply cables in the power supply buildings and in the tunnel. The overhead trays could be arranged as vertically stacked raceways to separate AC, DC and control/instrument cables. This is particularly important for the power cables that need more cooling than instrumentation/control cables.

For best life and reliability performance the Power Supply Controller (PSC) ADCs and DACs might best be placed external to the power supply so as not to subject them to power supply heat and noise. This would also be advantageous if standard, commercial power supplies are purchased. Care must be taken in grounding and shielding the interconnecting control cables.

The two RF power supplies are each 180 kW, 46 kV. IHEP has made a decision from two choices, a SCR crowbar type power supply and a pulse step (width) modulator power supply. They chose the pulse step modulator over the crowbar power supply because it will provide better stability. It also consists of 68 parallel-connected buck regulator modules that will be designed to fail in an open circuit mode. If one or two modules fail, the power supply can still function (although the output voltage might be diminished) and the replacement of an individual module is easier. The buck regulators alternate switch to increase the output frequency, resulting in a smaller output LC filter. The stored energy in the filter is considerably smaller than that of a 600 Hz SCR filter and thus a crowbar is not required. Even though insufficient detail was provided to fully evaluate the pulse step modulated power supply, in general the feeling is that IHEP made a good choice.

In the written report there is no mention of a Personnel Protection System (PPS), although, according to verbal statements by IHEP personnel, a PPS system is planned. It is suggested that the PPS system be redundant, very visible, and hardware-based as much as practical and distinctly separate from the machine protection system (MPS).

For the superconducting magnet power supplies there was no serious discussion in the design report of quench protection issues and their impact on power supply design (control, diagnostics, operation modes and interlock). We note that quench protection should go hand in hand with operation and monitoring of the gas cooled leads, the design of which was also not discussed.

A large number of switch-mode power supplies will be used. As correctly pointed out in Chapter 2 of the BEPC-II Design Report, electromagnetic compatibility is a necessity, particularly for conducted emissions from the power supplies. The Committee recommends the use of MIL-STD-461 or FCC Class A standards as an EMC benchmark. Radiation effects on the AC input line or the DC output cables are not significant, since the switching frequency that generates the harmonics is typically only 20 kHz.

IHEP is considering two types of bipolar output kicker power supplies (pulsers), one type would have a floating output and the other would employ a floating thyratron connected to a grounded output. Both approaches suffer from the disadvantage that a tri-axial output cable is needed. The inductances of the supply and return lines will be unbalanced. SLAC suggested a grounded, unipolar output pulser where the two ends of the slotted pipe kicker magnet are simultaneously fed from opposite ends. The Committee also asked IHEP consideration of a more reliable, low pulse-to-pulse jitter, solid-state design. SLAC Power Conversion Group would be happy to participate in the development of a solid-state pulser with IHEP.

Cryogenic Systems

Three systems at BEPC-II are superconducting: the two superconducting RF cavities; the two superconducting IR magnet assemblies; and the detector solenoid magnet. This is the first time superconducting technology has been used at IHEP.

The international collaboration with laboratories that have similar superconducting facilities should be encouraged. The cryogenic systems for these superconducting facilities will most likely be designed and fabricated by IHEP. The experience in accelerator operation using superconducting facilities has shown that the reliability of the cryogenic systems is one of the critical issues. Also, the construction of the helium refrigeration system at nearly 1 kW capacity might be one of the critical paths in the BEPC-II upgrade. Also, it represents a high percentage of the overall cost.

We note that the BEPC-II cryogenic system is needed for the final stages of superconducting magnet production since the first time the magnets will be cooled down and energized is after delivery to IHEP and this has significant schedule consequences. Thus the superconducting magnet power supplies, gas cooled leads, quench protection and control system and a new magnetic measurement system must be available well before installation in the accelerator is performed. Note that if it is desired to test the magnets in place in the experimental hall in order to avoid duplication of effort, then the superconducting magnet and BES-III detector construction schedules become strongly linked.

The cryogenic system design needs more attention than is apparent in the Design Report.

Alignment and Supports

The accelerator component support and alignment system should consider the photon stability requirements of the accelerator operating in the Synchrotron Radiation mode. This requires the careful consideration of the natural frequencies of the mechanical supports with the goal to increase the frequency beyond the lower frequencies usually encountered in the accelerator environment.

The mechanical alignment tolerances specified in the Draft Design Report are achievable but challenging. The proposed surveying equipment can meet these tolerances, although the number of observation points will need to be increased, particularly in the Interaction Region, if positioning at the level of 150 μm is to be achieved. Even with an increased number of observation points, the reviewers feel that the best global alignment of quadrupoles on opposite sides of the Interaction Point that can be achieved is 250 μm.

Motions of beamline equipment due to the expansion of supports with the variation of the environmental temperature over time should be investigated, particularly in the case of the large supports on either side of the BES-III detector.

The most critical and difficult magnet support and alignment challenge are associated with the SC magnets, cantilevered in the detector end caps. In the trim mode, the end currents of the corrector dipole also introduce transverse forces when coupled with the solenoidal field. These forces should be carefully evaluated at the maximum anticipated corrector current in the accelerator collision mode. The physical constraints of this area present especially challenging design issues which must consider support, alignment, installation and removal and access of the cryogenic and power lines. The design of the cryogenic SC module will need to coordinate closely with the needs of the detectors and the adjacent final bend septum magnet. The designs of these components cannot be developed in isolation.

In developing the plan for mechanical installation and alignment, it may be possible to eliminate one set of measurements and adjustments by carefully aligning beamline components to one another on the girder prior to transportation to the tunnel. All subsequent measurements and adjustments could then be made to the girder only, potentially reducing the amount of survey work to be performed in the tunnel.

Appendix A

BEPC-II Review
May 13-15, 2002, SLAC

Charge

The goal of the review is to determine, if built as described, will the BEPCII accelerator meet the operations and physics goals. Does the project schedule look reasonable? Identity the critical parameter choices and critical technical systems and components in the design. Suggest what improvements or changes are required and what prototyping and demonstrations are needed, if any. Comment on the proposed timeline.

Appendix B

BEPC-II Review
May 13-15, 2002, SLAC
Agenda

Time	Monday, 13th	Tuesday, 14th	Wednesday, 15th	Thursday, 16th
8:15	Exec. Session			
8:30	Bus leaves hotel	Bus leaves hotel	Bus leaves hotel	
9:00	J. Sheppard Plenary	4 Parallel Working Groups	G. Pei Plenary: BEPC-II replies to questions	
10:30	Break	Break	Break	
11:00	J. Sheppard Plenary	4 Parallel Working Groups	4 ParallelWorking Groups	
12:00		Joint WG1 and WG3		WG Reports Ready
12:30	Working Lunch	Lunch	Lunch	
13:30	A. Chao Plenary	Joint WG1 and WG2		
14:30		Joint WG1 and WG4		
15:00		Joint WG2 and WG3	G. Loew WG Summaries	
15:30	Break	Break		
16:00	A. Chao Plenary	Exec. Session		
17:00	4 Parallel Working Groups	C. Zhang Plenary: Reviewers ask questions	End	
18:00	End	End	Dinner SPEAR3	
18:30	Bus to Banquet	Bus to A. Chao	Car pool to San Jose	
19:00	Banquet	Dinner	Chinese performance	
21:00		Bus to hotel	Car pool to Hotel	
21:30	Bus to Hotel			

Plenary Session: Orange room (Central Lab.)
Working Group 1: Orange room
Working Group 2: Cascade room (Bldg. 212, Rm. 6)
Working Group 3: Orange room
Working Group 4: Green room (Central Lab., Rm. 319)

Appendix C

BEPC-II Review
May 13, 2002
Plenary Session Agenda

Morning Session, Chair: John Sheppard

Jonathan Dorfan	Welcome
Alex Chao	Logistics
Zhang Chuang	Overview Report
Xu Gang	Lattice Design
Wang Jiuqing	Impedance Issue
Pei Guoxi	Injector Linac Upgrade
Wang Guangwei	RF System
Zhao Jijiu	Control System
Cao Jianshe	Instrumentation
Ma Li	Bunch Feedback System

Working Lunch

Afternoon Session, Chair: Alex Chao

Dong Haiyi	Vacuum System
Yin Zhaosheng	Magnet System
Hao Yaodou	Injection Kickers
Cheng Jian	Power Supplies
Qu Huamin	Engineering Issues
Wu Yingzhi	Interaction Region
Chi Yunlong	Modulator & Klystron
Wang Yifang	Detector and Background Issue

Appendix D

BEPC-II Review
May 13-15, 2002, SLAC

Participants

Cao Jianshe, IHEP
Cheng Jian, IHEP
Chi Yunlong, IHEP
Dong Haiyi, IHEP
Hao Yaodou, IHEP
Ma Li, IHEP
Pei Guoxi, IHEP
Qu Huamin, IHEP
Sun Yaolin, IHEP
Wang Guangwei, IHEP
Wang Jiuqing, IHEP
Wang Yifang, IHEP
Wu Yingzhi, IHEP
Xu Gang, IHEP
Xu Tongzhou, IHEP
Yin Zhaosheng, IHEP
Zhang Chuang, IHEP
Zhao Jijiu, IHEP

Paul Bellomo, SLAC
Sergey Belomestnykh, Cornell
Alex Chao, SLAC
John Corlett, LBNL
Scott DeBarger, SLAC
Jonathan Dorfan, SLAC
Stan Ecklund, SLAC
Bob Hettel, SLAC
Rusty Humphrey, SLAC
Lin X. Jia, BNL
Lowell Klaisner, SLAC
Greg Loew, SLAC
Brett Parker, BNL
Dave Rice, Cornell
Marc Ross, SLAC
John Seeman, SLAC
John Sheppard, SLAC
Mike Sullivan, SLAC
Jack Tanabe, SLAC
Pief Panofsky, SLAC