To: **Distribution**
From: **GDE Change Control Board**
Subject: **Response to the Change Request (October 30, 2006) for the BCD Main Linac (ML) Section – CCR#20**

Preamble

This is the CCB response to the proposed changes to apply to the Main Linac (ML) section of the November 5, 2006 version of GDE ILC Baseline Configuration Document [1]. CCB received the change configuration request (CCR#20) from C.Adolphsen on October 30, 2006 [2], and CCB forwarded it to GDE the same day. It was initially classified as Class-2 and it was confirmed as such at the CCB hearing that was held during the Valencia GDE meeting on November 9, 2006 [3]. C.Pagani, W.Funk and S.Mishra were assigned as the CCB reviewers.

Summary

Requester proposed:

To apply three changes in the ML design baseline:

CCR#20a: Change of the cryomodule (CM) layout driven by each of the 10MW klystron RF unit. Previously, with two 8-cavity without a magnet and one 8-cavity with a magnet (8-8-8). Now, with two 9-cavity CM without a magnet and one 8-cavity with a magnet (9-8-9). Thus, 26 cavities are driven by one 10MW klystron rather than the previous 24. Consequently, the maximum achievable accelerating gradient is 33.5MV/m rather than 35MV/m assuming use of WR770 waveguides for improved RF transmission.

CCR#20b: Elimination of RF unit overhead. Previously, 3.5%. Now, 0%. Thus, maximum beam energy 250GeV is available only if all RF units are in operation and all CMs together with their cavities.

CCR#20c: Elimination of the uncertainty factor in the cryogenic static heat load. Previously, 50%. Now, 0%. This allows to lower the cryogenic capacity by 13%.

CCB response:

1. CCB found that the cost impact of the three changes CCR#20a, b and c amounts to a total 5.2% reduction of the construction cost of ML, including that of related conventional facilities. If individually looked at, only CCR#20-b qualifies as Class-2 (CCR#20-a and CCR#20-c each belong to Class-1 category). In the light of important implications and relative relationship among three changes, however, CCB has decided to make recommendations to EC for all of CCR#20-a, #20-b and #20-c, rather than to make a final configuration change decision separately for #20a and #20c.

2. CCB recommends EC, on the basis of its review as detailed in the "Discussion" session of this report:

    A. To not accept CCR#20a.
    B. To not accept CCR#20b.
    C. To not accept CCR#20c.

3. CCB finds that to proceed further on design development of ML system, together with design development of other systems who rely on the hardware equipment derived from ML, some clarifications in the BCD text is urgently required in at least three areas. CCB recommends EC:

    D. To instruct relevant parties to resolve conflicting descriptions of beam parameter specifications in the BCD.
    E. To instruct relevant parties to introduce a place holder for clear and unmistakable definition of the energy reach and luminosity reach of ILC phase-1 in the BCD and to introduce descriptive entries there.
    F. To instruct relevant parties to redraft a specification table as part of BCD for the main linac RF unit, together with cavities and cryomodule, on the basis of a firm consensus of all subgroups who are involved such as: parameters, high-level RF, low-level RF, cavities, cryomodules, cryogenics, commissioning, operation and availability. This specification table has to allocate reasonable provisions for absorbing the current technical ambiguities, has to be internally consistent, and has to be consistent with respect to the definition of the "energy reach" above.

Discussion:

CCR#20a

Statements contributed by relevant parties:
1. Requester gave the following statements:
    -   Cost reduction associated with this proposed change comes from reduction of the number of RF units to build by factor 1/13. It amounts to 1.2% of the total ML construction cost.
    -   Accounting of the RF power in requester's view is described in the minutes of the CCB hearing for CCR#20 [3]. In the present 8-8-8 configuration (i.e. prior to applying CCR#20a) in requester's estimate approximately a 10.9% tuning range is provided with the LLRF system before reaching the maximum gradient of 35MV/m. In the proposed 9-8-9 configuration approximately a 9.6% tuning range is available for LLRF system before reaching the maximum gradient of 33.5MV/m.
2. K.Yokoya, during the CCB hearing for CCR#20, noted that the specifications for the beam current in the present BCD have conflicting descriptions. The following parameter set was agreed on at the time of Frascati GDE meeting in December, 2005, and they have been reflected in the Damping Ring section of BCD and in requester's statement for CCR#20, but not in the BCD Parameter section:
    -   Bunch spacing: 337 ns
    -   Bunch intensity: 2×10^{10}
    -   Bunch train length   1 ms
    -   Beam current: 9.5 mA
3. S.Michizono, B.Chase and S.Simrock contributed a set of comments [4] recommending to allocate at least 10% of power overhead for suitable operation of the LLRF feedback system. In addition, they stated the following, among others:
    -   Since one of the critical "knobs" in the LLRF feedback is the klystron drive which controls the output of klystrons operated in a non-saturated regime, the nominal operating point of klystrons should be at least 3% below the saturation point for the LLRF control to be effective.
    -   Non-flatness of modulator pulses needs to be compensated for by the LLRF feedback, and an allowance should be accounted for either in terms of the LLRF overhead or modulator efficiency or klystron output power rating.
    -   Good stability of the operating condition is an important prerequisite for satisfactory operation of the LLRF system, including: beam intensity (for stable beam loading), modulator voltage, Lorenz force detuning, klystron noise sideband and others.

    CCR requester (C.Adolphsen) responded that approximately 10% power overhead for LLRF is indeed allocated in his evaluation [5].
4. S.Nagaitsev, R.Pasquinelli, J.Reid, O.Nezhevenko, B.Chase and G.Canelo contributed remarks [6]. They stated
    -   Klystron performace towards its life end degrades by 5% or up to 10%, and that fact should be taken into account.

- In addition to the power loss in WR650 or WR770, the loss within circulators should be taken into account. Overall losses in the WG system should be considered 8% rather than 5% as estimated by CCR requester.

CCR requester (C.Adolphsen) responded that performance specification (10MW output power) for klystrons has to take the degradation into account. [9,11]

5. B.Chase, S.Michizono and S.Simrock contributed a worksheet [7] which summarizes the accounting of various factors that lead to power loss or that need to be allocated as allowance for LLRF tunability. In response to CCB inquiry [8], comments on this attempted summary were contributed by C.Adolphsen [9] and by S.Nagaitsev [10].

CCB Discussion:

6. CCB's summary of RF power accounting is attached in Appendix A1 for the 8-8-8 configuration (prior to applying CCR#20a) and Appendix A2 for the 9-8-9 configuration (after applying CCR#20a). The tables in Appendix A1 and A2 lists various types of RF loss factors or tuning overhead factors as quoted by requester (Adolphsen), the contributions by Chase et al [7] and CCB's assessment:

   - CCB feels that "de-rating" of klystron performance towards the end of its lifetime should be part of the klystron specification, rather than part of the RF loss factors to assume. In other words, the performance of klystron ought to be specified such that it provides the system with 10MW towards the end of its (individual klystron's) life. Only if this is found to mean an unsurmountable challenge for the klystron engineering, the de-rating factor should become part of the RF loss factors. CCB notes that a suitable elaboration of the klystron performance description in ML part of BCD is worth.

   - CCB feels that modulator ripples can be said to be part of the modulator efficiency, rather than part of the RF loss factors, although, again, it has to be explicitly stated and noted as such in BCD for all who are concerned with the ML RF system.

   - CCB considers that cavity-to-cavity performance variation (gradient, Q) is inevitable and it has to be part of this accounting exercise, although it is very hard to determine a credible number at this point of development. CCB feels that it is probably adequate to consider 2.3% for it for now. There is another potential issue of time-dependent degradation of cavity performance as quoted in experience at Jefferson Lab. CCB tentatively chooses not to consider this latter issue, pending further operational experiences to be accumulated in a manner translatable to the environment at ILC.

   - While the amount of RF loss within waveguides and circulators might be reduced by use of inner surface copper coating, since it is not part of the explicit change request proposal, CCB finds it more reasonable to tentatively assume 7% loss in WR650, 5% loss in WR770 and 3% loss in circulator.

   - Specific numbers for the quoted LLRF loss/tuning factors are, naturally, subject to model-dependent evaluation. In addition, whether to take their linear sum or a square sum is an unresolved issue. Thus, both cases with linear and square sums are quoted under the CCB column.

   - CCB finds in its own version of evaluation that

1. Case 8-8-8 gives a tuning range to reach the peak gradient of 32.3MV/m (34.2MV/m) when a linear (square) sum of LLRF loss/tuning factors are considered.
2. Case 9-8-9 gives a tuning range to reach the peak gradient of 30.44MV/m (32.3MV/m) when a linear (square) sum of LLRF loss/tuning factors are considered.

CCB Assessment

- CCB agrees that the BCD parameter section has to be updated expeditiously in accordance with the finding that has been pointed out in CCR#20a-2. The definition of the canonical beam current directly affects the required amount of RF power to support operation at any given goal of the accelerating gradient in the cavities. CCB endorses the parameter set proposed by Yokoya in CCR#20a-2.
- CCB finds that in the present accounting of RF power, the case 9-8-9 as proposed with CCR#20a has a possibility of not being able to support operation of 31.5MV/m gradient on average.
- CCB notes that with suitable performance improvements or design improvement of the components within the ML system, and with due coordination of efforts by all concerned parties within the ML system, together with the parameter and electron source groups, the 9-8-9 configuration might be made more likely to "work comfortably". However, it is CCB's observation that these discussions and studies have not yet converged, at this moment, to a level that can be called to form a collective consensus by all who are involved.
- Consequently, CCB finds it inadequate to recommend approval of CCR#20a as is, at this moment.
- CCB also notes that the present 8-8-8 configuration has a possibility of allowing ILC substantially lower RF headroom than claimed by the CCR requester. In one of the "worst" case scenarios, it allows us to operate only at 32.3MV/m, merely 2.54% higher than the designated average gradient.

CCR#20b

Statements contributed by relevant parties:

1. Requester noted the following:
   - Cost reduction associated with this proposed change is 3.5% of the total ML construction cost including the expenses needed for conventional facilities.
   - The proposed elimination of 3.5% energy overhead is associated with elimination of the 3.5% worth of the ML tunnel lengths.
   - If the cavities produce average gradient of 31.5MV/m as in the present BC, 250GeV beam energy could only be achieved if there are no failed RF units and cavity units
   - If the cavities are able to operate at 33.5MV/m, as limited by the RF capacity in requester's proposal, there would be a 6% overhead.

2. H.Yamamoto, a co-chair of WWS, responded to CCB inquiry from the physics standpoint. His response (two emails) is reproduced in Appendices B1 and B2. Yamamoto stated that elimination of 3.5% energy overhead is acceptable if 3.5% worth of ML tunnel lengths are still maintained to allow installation of additional 3.5% of ML hardware. This is for retaining the operational capability at the top energy (250GeV beams) in the future. In his email communication Yamamoto is referring to "GDE statement", which CCB interprets as statements made by GDE member(s) at the time of the WWS meeting, rather than statements made by CCB which did not have a presence then.

3. R. Heuer, chair of the ILCSC Parameter Group, reported on his group's activity at Valencia GDE meeting. Heuer's presentation material is available as http://ilcagenda.cern.ch/getFile.py/access?contribId=9&sessionId=14&resId=1&materialId=slides&confId=1049. Slide 16 of his presentation states:

   > "Highest possible energy is called for but at present there is no known measurement which could not be done at slightly reduced energy. Removing safety margins in energy reach is acceptable. Maximum luminosity is not needed at the top energy (500GeV). However, 500GeV should be reachable assuming nominal gradient before knowing more about physics scenarios realized."

   Although the Group's final written report is not available, Heuer, during the Valencia meeting, informed Toge that the contents of the report will be most likely consistent with his presentation.

CCB Discussion:

4. Each ML has approximately 300 RF units. Consequently, if MTBF of each klystron is 40,000 hrs and MTTR is 12 hrs, one RF unit is not operational in each of the MLs for approximately 10% of the time (likewise, two RF units to be down for ~0.5% of time, and three RF units down for ~0.017% of time). A loss of one RF unit means an energy loss of ~0.3% in case of 250GeV beam. In addition, losses of RF units can happen in transient ways, caused by trips of klystrons or modulators. In this latter case an energy feedback system could make compensation and stabilize the energy, if adequate provisions are made for RF units to use for such purposes. In any case, at minimum, several surplus RF units should be reserved from the RF availability standpoint, so as to ensure seamless ML

operation for any given target energy. This corresponds to at least ~1% of the top beam energy gain.

5. In addition, there would be some number of cryomodules/cavities which become non-operational for a variety of reasons at any moment during operation. Hoping for a MTBF for the cavity package as high as one million hours, we might still see as many as 128 cavities to be lost in one year, i.e. 0.8% of the peak energy.

6. Losses of RF units or cavities, if they are *static*, can be compensated by reducing the beam current, but with the same RF drive, meaning at the cost of reduced luminosity. Since the positron intensity is directly connected to the electron intensity, actual operational procedure requires an intelligent control system but it is expected to be possible. An issue with this operation is that the average gradient of the cavities needs to be raised above the canonical 31.5MV/m. Compensation of losses of RF units or cavities are possible also by increasing the RF drive on a selected set of cryomodules which are known to have a superior gradient reach beyond 31.5MV/m.

7. The present BCD states that cavities in ML should operate at 31.5MV/m gradient on average. BCD also states that the individual cavities are validated up to 35MV/m prior to installation in cryomodules. This implies to many members within GDE that some cavities after installation at ILC ML could operate at a gradient somewhat higher than 31.5MV/m. However, no numerical or definitive statements are given on the projected performance of cavities at gradients higher than 31.5MV/m after installation in the present BC. Consequently, present discussion of the ILC energy reach, which solely depends on the cavities possibly performing better than 31.5MV/m, has to be noted as being without numerically specific statements of technical commitment by relevant parties working on superconducting cavities.

8. Concerning the remark from WWS representative, assuming for now that ILC incorporates a 3.5% reserve tunnel yet without actual ML hardware to go with it, if and when found necessary to add the 3.5% worth of ML hardware, it would mean a significant interruption of operation for a relatively small energy gain. There is a significant uncertainty if this idea of 3.5% reserve tunnel (yet without initial installation) is a viable option in the light of realistic mid-/long-term operational model.

9. The representative of ILCSC Parameter Group stated that the energy reach of 500GeV should be retained, while the luminosity might be compromised. If and when this statement becomes one of the official design requirements for ILC, it would be GDE's responsibility to redefine and/or restate the specific numbers for the target energy reach *together with* the extent of luminosity compromise to take, for all within the design team. This has not yet taken place as of now.

CCB Assessment:
- Results of very simple evaluations in CCR#20b-4 and CCR#20b-5indicate that the present 3.5% allocation of energy overhead on *top of the agreed-upon peak energy* is not an unreasonable premise. The amount of energy overhead *might* be reduced, if and when more refined availability evaluations are made. However, new results of any such studies have not yet been made available to CCB in conjunction with CCR#20b.
- Other important aspects to consider are observations and discussions in CCR#20b-6, 7 and 9. On their basis, CCB finds that it is inadequate to recommend approval of CCR#20b as is, in

response to a change request from the leaders of the ML Area Group Leaders *only*. Because of the observation in CCR#20b-8, CCB also finds inadequate to recommend an alternative scenario in which to retain 3.5% worth of ML without the associated ML hardware.

CCR#20c

Statements contributed by relevant parties:
1. Requester noted the following:
   - CCR#20c seeks to eliminate only the uncertainty factor (presently 50%) in the cryogenic static heat load.
   - The 40% overcapacity factor on the total load, which is a combination of both the static and dynamic, is not changed. This overcapacity factor consists of: 20% provision for system degradation, 10% provision for control, and 8% provision for warm season's conditions.
   - The net reduction of the cryogenic capacity is 13%.
   - The cost reduction associated with this proposed change is 0.5% of the total ML construction cost, including the expenses needed for conventional facilities.
2. T. Peterson and L. Tavian, in response to CCB request, provided a detailed description of how the cryogenic heat load for ILC has been evaluated (Appendix B of [3]) and how they would match the changes proposed with the rest of CCR#20 (i.e. CCR#20a and CR#20b). Towards the end of the write-up Peterson stated as follows
      "Peterson's opinion is that capacity based on 33.5MV/m, uncertainty factor 1.0, overcapacity factor = 1.4, would be a good design criterion for a cryogenic system in response to CCR#20."

CCB Assessment
- CCB finds the evaluations on the heat load by Peterson and Tavian to be very thorough and reasonably credible. CCB agrees that if CCR#20a is to be accepted and the peak gradient of the ML cavities to consider is agreed as 33.5MV/m, Peterson's statement in CCR#20c-2 could be considered a reasonable working assumption.
- CCB, however, notes that CCB's position regarding CCR#20a is negative. As such, and with the opinion in agreement with Peterson's philosphy in CCR2#20c-2, CCB considers it is more adequate, at this moment, to consider taking "the heat capacity based on 35MV/m, uncertainty factor 1.0, overcapacity factor=1.4" as the baseline, pending further clarifications on the energy reach, luminosity reach, ML RF unit layout and other issues.
- Therefore, CCB finds that it is inadequate to recommend approval of CCR#20c before the issues related to CCR#20a and #20b are resolved.

Costing Issues

Below is an excerpt from the minutes of the CCB hearing on CCR#20 [4].

- Summary of the cost impacts is as follows

   CCR#20a: 1.2% reduction
   CCR#20b: 3.5% reduction
   CCR#20c: 0.5% reduction

   The proposed change CCR#20b, qualifies as Class-2 alone, but not CCR#20a nor #20c. When three proposals are put together, naturally the entire CCR#20 qualifies as Class-2.

- The "total ML construction cost" here includes the cost for the conventional facilities related to ML.

- The calculation of the percentage cost changes is based on a total ML cost which uses the scaled TESLA estimates for the cryomodules.

Overall CCB Assessment:

1. Since details of CCB assessment on CCR#20a, CCR#20b and CCR#20c are individually presented in previous section, they are not repeated here.

2. CCB considers that to proceed further with discussion on adequacy of a basic design of an RF unit at ILC, and to make progress on a type of issues such as CCR#20a, the following points must be noted:

   - The Parameter section of BCD has to be updated so as to correct the situation pointed out in CCR#20a-2.

   - A specification table for ML subsystem components has to be created for BCD as a result of consultation of all concerned parties in a way consistent among themselves as well as with respect to the overall design of ILC.

   - An advanced version of RF power accounting table whose prototype was presented in Appendix A1 and A2 should be drafted as a result of group consultation, and again, should be made part of BCD.

   - CCB realizes that in case of technical ambiguities, a choice has to be made between an optimistic projection and a pessimistic safety factor. Either ways, the choice should be made as result of group-wide consultation and agreement.

3. CCB considers that to proceed further with discussion on the energy goal for ML group to guide its own design efforts, GDE as a whole first should make clear definitions of the energy reach and luminosity reach for ILC (or their compromises in conjunction with physics, availability and cost optimization).

   - CCR#20b has been instrumental in illuminating many of the issues related to this particular topic, and CCB considers that its review process has been very useful for, at least, CCB. CCB, however, considers that it is inadequate to let the ML group carry the sole burden of practically redefining the energy (or luminosity) reach solely from its cost-reduction standpoint.

   - As noted in CCR#20b-3 and #20b-4, approximate guidelines are expected to come out shortly from the ILCSC parameter group to the extent that can be presented from the standpoint of high-energy physics research. CCB considers that it is the responsibility of

GDE EC (or a suitable executive body under EC to oversee the whole ILC design) to translate these guidelines into specific numbers that can be shared and understood by all engineering-oriented experts within the GDE design team, before proceeding.

4. CCB's conclusions as the result of these deliberations are as presented in "CCB response" under "Summary".

Additional Notes:

Handling of Cost-Related Information:

The "Hearing" on the cost impacts was held as a face-to-face meeting on November 8, 2006 during the GDE meeting at Valencia. The minutes of the hearing are available in [4]. However, as announced by GDE EC and reported at the Vancouver GDE meeting all public communication from CCB will have all "raw" cost numbers withheld (replaced by fractional numbers wherever possible and adequate).

RDR and BCD

In response to CCB inquiry regarding CCR#20, the requester made a few statements to the effect: "details will be made available in RDR". CCB wishes to remind the requester that it is the BCD which is expected to define the baseline configuration of ILC design, including adequate numerical tables to summarize and illustrate the specifications of each of the ILC accelerator subsystems and their critical components, *not* RDR which is not under configuration control. RDR is supposed to be authored according to descriptions in BCD, not the other way around. At the risk of being repetitive, since the Vancouver GDE meeting, CCB thus urges all leaders of GDE Area Groups to strive for updating relevant entries of BCD without excessive delays if hitherto undocumented design features are to be recorded in RDR.

E N D

References

[1]   http://www.linearcollider.org/wiki/doku.php?id=bcd:bcd_home .

[2]   C.Adolphsen: http://lcdev.kek.jp/ML/PubCCB/msg00120.html

[3]   Minutes of CCB Hearing, Nov.9, 2006.
      http://www.linearcollider.org/wiki/lib/exe/fetch.php?cache=cache&media=bcd:ccr20hearingml
      20061109.pdf

[4]   S.Michizono, B.Chase and S.Simrock: http://lcdev.kek.jp/ML/PubCCB/msg00121.html . Also,
      S.Michizono: http://lcdev.kek.jp/ML/PubCCB/msg00122.html .

[5] C.Adolphsen: http://lcdev.kek.jp/ML/PubCCB/msg00104.html .

[6] S.Nagaitsev et al.: http://lcdev.kek.jp/ML/PubCCB/msg00123.html .

[7] B.Chase, S.Simrock and S.Michizono: http://lcdev.kek.jp/ML/PubCCB/msg00124.html .

[8] N.Toge: http://lcdev.kek.jp/ML/PubCCB/msg00125.html,
      http://lcdev.kek.jp/ML/PubCCB/msg00126.html .

[9] C.Adolphsen: http://lcdev.kek.jp/ML/PubCCB/msg00127.html .

[10] S.Nagaitsev et al: http://lcdev.kek.jp/ML/PubCCB/msg00118.html .

[11] S.Michizono et al: http://lcdev.kek.jp/ML/PubCCB/msg00128.html .

Appendix A1

RF power accounting in case of "8-8-8" configuration. Estimates by (1) C.Adophsen, (2) B.Chase, and (3) CCB are compared.

	Adolphsen (20061106)			Chase (20061116)			CCB (20061123)		
	Voltage loss	Power loss	Available Power (MW)	Voltage loss	Power loss	Available Power (MW), when 5% derating of klys is considered	Voltage loss	Power loss	Available Power (MW), when no derating of klys is considered
Power Source and High Level RF Loss Factors									
Maximum Klystron Output Power		0.0%	10		0.0%	10.00		0.0%	10.00
De-rating of klystron for end of life time		0.0%	10		5.0%	9.50		0.0%	10.00
Modulator Ripple Spec = 1% (Often worse)	1%	0.0%	10	1%	2.5%	9.26	1%	0.0%	10.00
Waveguide and circulator losses		5.0%	9.5		8.0%	8.52		8.0%	9.20
Power loss due to cavity gradient variation		0.0%	9.5		2.3%	8.33		2.3%	8.99
Parameter variation	0.5%	0.0%	9.5	0.5%	1.0%	8.24	0.5%	1.0%	8.90
Total HLRF Loss and Available Power		**5%**	**9.5**		**18%**	**8.24**		**11%**	**8.90**
Low Level RF Loss/Tuning Factors									
Peak power headroom				1.0%	2.0%	8.08	1.0%	2.0%	8.72
Dynamic Headroom				3.0%	5.9%	7.60	3.0%	5.9%	8.21
Beam current fluctuations of 1% pk				1.0%	1.0%	7.52	1.0%	1.0%	8.12
Detuning errors of 30 Hz				1.0%	2.0%	7.38	1.0%	2.0%	7.96
Klystron drive noise sidebands					2.0%	7.23		2.0%	7.80
Total LLRF Loss (linear sum) and Available Power		**9.6%**	**8.59**		**12.3%**	**7.23**		**12.3%**	**7.80**
Total LLRF (square sum) and Available Power		9.6%	8.59		6.7%	7.69		6.9%	8.28
9-8-9 Configuration Case									
Power (kW) Required for 9.5ma @ 33.5 MV/m			0.330344			0.330344			0.330344
Power (MW) for 26 cavities			8.59			8.59			8.59
Excess Power Headroom (when linear sum of LLRF losses assumed)			**(0.00)**			**(1.36)**			**(0.78)**
Excess Power Headroom (when square sum of LLRF losses assumed)			**(0.00)**			**(0.90)**			**(0.31)**
Peak Gradient (MV/m) at 9.5mA with 26cavities, when zero power headroom is assumed for linear-sum LLRF loss			33.50			28.19			30.44
Peak Gradient (MV/m) at 9.5mA with 26cavities, when zero power headroom is assumed for square-sum LLRF loss			33.50			30.00			32.31

Appendix A2

RF power accounting in case of "9-8-9" configuration. Estimates by (1) C.Adophsen, (2) B.Chase, and (3) CCB are compared.

	Adophsen (20061106)			Chase (20061116)			CCB (20061123)		
	Voltage loss	Power loss	Available Power (MW)	Voltage loss	Power loss	Available Power (MW)	Voltage loss	Power loss	Available Power (MW)
Power Source and High Level RF Loss Factors									
Maximum Klystron Output Power		0.0%	10		0.0%	10.00		0.0%	10.00
De-rating of klystron for end of life time		0.0%	10		5.0%	9.50		0.0%	10.00
Modulator Ripple Spec = 1% (Often worse)	1%	0.0%	10	1%	2.5%	9.26	1%	0.0%	10.00
Waveguide and circulator losses		7.0%	9.3		10.0%	8.34		10.0%	9.00
Power loss due to cavity gradient variation		0.0%	9.3		2.3%	8.14		2.3%	8.79
Parameter variation	0.5%	0.0%	9.3	0.5%	1.0%	8.06	0.5%	1.0%	8.71
Total HLRF Loss and Available Power		**7%**	**9.3**		**19%**	**8.06**		**13%**	**8.71**
Low Level RF Loss/Tuning Factors									
Peak power headroom	1.0%			1.0%	2.0%	7.90	1.0%	2.0%	8.53
Dynamic Headroom	3.0%			3.0%	5.9%	7.44	3.0%	5.9%	8.03
Beam current fluctuations of 1% pk					1.0%	7.36		1.0%	7.95
Detuning errors of 30 Hz	1.0%			1.0%	2.0%	7.21	1.0%	2.0%	7.79
Klystron drive noise sidebands	1.0%			1.0%	2.0%	7.07	1.0%	2.0%	7.63
Total LLRF Loss (linear sum) and Available Power		**10.9%**	**8.29**		**12.3%**	**7.07**		**12.3%**	**7.63**
Total LLRF (square sum) and Available Power		**10.9%**	**8.29**		**6.7%**	**7.52**		**6.9%**	**8.10**
8-8-8 Configuration Case									
Power (kW) Required for 9.5ma @ 35 MV/m			0.345135			0.345135			0.345135
Power (MW) for 24 cavities			8.28			8.28			8.28
Excess Power Headroom (when linear sum of LLRF losses assumed)			**0.00**			**(1.21)**			**(0.65)**
Excess Power Headroom (when square sum of LLRF losses assumed)			**0.00**			**(0.76)**			**(0.18)**
Peak Gradient (MV/m) at 9.5mA with 24cavities, when zero power headroom is assumed for linear-sum LLRf loss			**35.01**			**29.88**			**32.26**
Peak Gradient (MV/m) at 9.5mA with 24cavities, when zero power headroom is assumed for square-sum LLRf loss			**35.01**			**31.79**			**34.24**

Appendix B1

Subject: CCR 20 - elimination of RF overhead
From: Hitoshi Yamamoto
To: Nobu Toge
Date: Tue, 14 Nov 2006 14:41:30 +0900

Dear CCB,

The WWSOC held a meeting on Nov. 8 to discuss the change control request No. 20 which is to eliminate the 3.5% overhead of RF capacity.

We have concluded that we would not oppose to this CCR provided that some measure is taken to make the change reversible with reasonable effort. The maximum energy range of the 500 GeV machine is critical for important SM modes such as tth , Zhh, and possibly for some SUSY scenarios.

Also, we take this opportunity to express our concern in general with cost-cutting measures which jeopardize the full physics capability of the machine, particularly when they do so irreversibly.

WWS co-chairs

Appendix B2

Subject: Re: Minutes of CCB Hearing on CCR#20 (Draft A)
From: H.Yamamoto
To: N.Toge
Date: Wed, 15 Nov 2006 02:16:01 +0900

Dear Toge-san and CCB

The reply by WWS on CCR20 was based on the 'promise' by GDE that the tunnel will be extended in the baseline so that the 3.5% overhead can be recovered later if needed.   There was a question in WWS on how that was to be done, and the question was asked to Andrei before the WWS's reply was sent to CCB. The question was how the 3.5% is recovered in terms of the RTML location. Since there is a 60 m diameter 180 deg turn at the end of the linac, if the proposed linac without 3.5% overhead is built with the 180 deg turn at the end of the shortened linac, then in order to recover the 3.5% overhead, the 180 deg turn with the BCs and spin rotators would have to be moved over the distance of about 350m. This does not seem to be a trivial operation. Andrei said it is a good question and promised to talk to PT on this. No reply yet. But since we understand that the time is very tight for GDE, we sent our reply to CCB anyway.

The only realistic interpretation of what is proposed by GDE seems to be that the baseline would be the linac with 3.5% overhead with the RFs just enough to achieve 500 GeV when all cavities are working. Namely, the linac length is the same as the current baseline and there is about 350m of drift section where RF can simply be installed later. How much cost saving in this case? Does it make sense to make it the baseline?

Best regards

- Hitoshi