On Choice of Cavities to Install at STF Phase-2 of KEK

KEK LC Project Office, April 7, 2008

1. Introduction

Since the technology decision in 2004, in the area of cavity development the KEK group has been pursuing two, distinct cavity shapes - TESLA-like and Low-loss, aka LL. However, as the KEK LC office announced in the beginning of JFY2007, we would like to sort out the development programs for SRF cavities with the start of JFY2008. This is so as to make a clearer prioritization of the efforts and an optimized resource allocation associated with them. The background for making such a decision, at this point, is two-fold:

- Difficulties exist in maintaining the budget and human resources to pursue the two programs on equal footing.
- The present plan for the STF Phase2 assumes that JFY2008 is spent on the design efforts of the cavity and cryomodule, JFY2009-10 on construction, test, installation, and JFY2010- on system operation. While this schedule might see some delays due to budget constraints and might be also paced by STF Phase-1, some of the main system specifications need to be frozen before long, and thus, the cavity shape to use at STF Phase2 needs to be determined when the budget plans are put in place for JFY2008.

In this meanwhile, GDE, in early 2008, has revised its mid-range plan in accordance with recent budget issues in Europe and North America. Rather than preparing the Engineering Design Report by mid-2010, as assumed in the past, the current GDE schedule envisages that:

- Technical Design Phase 1 (TDP1), toward mid-2010, would focus on a selected set of high-priority development programs and cost studies.
- Technical Design Phase 2 (TDP2), toward 2012, would complete the Technical Design of ILC in sufficient details that project approval from all involved governments can be sought.
- Detailed engineering design and industrialization of needed technologies would continue toward commencement of ILC construction.

As for the SCRF milestone, the present TDP plan aims to achieve the high-gradient cavity performance at 35MV/m with the production yield of 50% in TDP1 and 90% in TDP2. Design work of crymodules is another focus items in TDP1. The present plan states that by the end of 2009 the design the normal ILC cryomodule, including optimization of thermal balance and cryogenics operation as well as beam dynamics (component orientation and alignment), is to be completed. This is to be followed in 2010 by operation of cryomodules in all three regions, and to have at least one cryomodule record an average gradient of 31.5MV/m, constructed with contributions from all three regions,. Then a critical task to carry out in TDP2 is to test an extended system which contains three cryomodules that are powered by a single RF power distribution source. This means construction and operation of one ILC RF unit and establishment of needed technologies. This work corresponds to STF Phase2 in case of KEK. The timescale for this TDP2 goal and STF Phase2 plans are consistent.

The completion time-scale of Technical Design, the year 2010, apparently calls for final selection of ILC cavities to be made near the end of TDP1. While the KEK selection of the cavities to install in STF Phase2 in 2008 is substantially ahead of it, such a timeline is appropriate in consideration of engineering lead time as well as from the standpoint of leading the technical decision making process by GDE. The STF Phase2 is an effort to push ahead construction of a unit prototype system of the ILC main linac.

In a large-scale, global project like ILC, an adequate balance has to be taken between enforcement of common design specifications and allowance for regional design variations. The former obviously brings in the benefits of technical simplicity and maintainability, while the latter brings in a healthy competition which is expected to lead to improved performance and reduced cost. The concept of "plug compatibility" is being introduced to facilitate both of these aspects. The "plug-compatibility" provides clear specifications for spatial, functional and other interface conditions for critical components, such as cavities. Regional groups are allowed to develop hardware components with their own kind of technical optimization in as much as they follow the compatibility specifications. The design of STF Phase2 is likely to precede what would be presented in the ILC Technical Design, and as a consequence, its details would differ. However, in as much as the "plug-compatibility" specifications are met, the STF Phase2 still should serve as a prototype ILC linac system. Similarly, the cavity shape may be revised, even at a much later stage, as long as relevant compatibility specifications are met.

We at KEK see three flavors of cavity shapes worth consideration:

- So-called, TESLA-short, which is a derivative of the original TESLA shape, and is the current GDE baseline,
- TESLA-like cavity newly proposed at KEK,
- Low-Loss type cavity shape.

The couplers, tuners and the Helium jacket are also subjects of selection, in terms of the design decision for STF Phase2, although they are somewhat separated from the choice of the cavity shape.

The KEK LC office has been holding several meetings with relevant members inf the KEK LC group to examine this issue since Summer, 2007. In the first step, both the TESLA-like cavity team and the LL cavity team were invited to present the rationale for their design schemes in comparison with other cavity designs, including the TESLA-short. In the second step, a series of Q/A sessions took place. They were done in the form of face-to-face meetings and in exchanges of written materials. The LC office attempted to digest and summarize the points given in these discussions, and proceeded with the analysis of the choice issue from various standpoints. The guidelines that the LC office kept in mind while making a decision are as follows:

(1) STF Phase2 is expected to serve as a test facility for the linac accelerator system, not limited to that for the cavity systems. The cavities and their associated hardware are required to perform as flawlessly as possible, to allow smooth testing of the overall system. The requirement goes beyond that of the simple gradient reach.
(2) STF Phase2 aims to spearhead the world effort toward valid implementation of the ILC main linac system and toward industrialization of relevant technologies. The cavity design, for KEK to focus there, should be consistent with the plug-compatibility guidelines as being developed at GDE, should satisfy the ILC specifications, and should be competitive with or hopefully superior to the TESLA-short both in terms of performance and cost.
(3) To attain concurrence and acceptance by colleagues in the entire GDE, the analysis and presentations on the cases for the cavity shape to pursue have to be well organized and traceable in each of “theories”, “calculations”, “simulations” and “validation with experimental data”. While recognizing the effort of relevant teams, the LC office has to keep eyes on how their outputs in these aspects fare.
(4) To attain multiple goals of STF Phase2 in a timely fashion, it is highly desirable to minimize schedule delays of the construction due to problems with cavity design and fabrication, including debugging. While recognizing the inevitable technical ambiguities in this type of R&D, we also must recognize our responsibility in maximally preempting such issues with good planning and foresight. The LC office has to keep eyes on how the technical ambiguities are put under control by the two cavity teams so as to clear the milestones at STF Phase 2 within the timescale of 2-3 years.

2. Conclusions

Conclusions by the KEK LC office are as follows:

(A) STF Phase 2 KEK adopts TESLA-like cavities.

(B) TESLA-like cavities has to satisfy GDE's Plug-compatibility requirements. The relevant team members must contribute to the development of Plug-compatibility guidelines, and, once agreed, must design and build the cavity systems at STF Phase2 in ways to satisfy these Plug-compatibility requirements, including the design and implementation of couplers and tuners.

(C) Development continues on the LL-cavities, as construction and testing of cavities, in the light of maintaining certain future possibilities. However, peripheral component development associated with the LL-cavities, such as the couplers and tuners, is halted.

Following are the reasons for choosing the TESLA-like cavity:

- On Lorentz detuning corrections: TESLA-like cavity sees a fair consistency between the calculations and experiments. Although the accelerating gradient that has been tried in this study is still low, an evaluation is under way to make a comparison with TESLA-short. LL-cavity saw a substantial progress during the measurement at STF0.5 in March, 2008. However, the cross examination between theoretical calculations and measurements remains at an early stage.
- On HOM damping: TESLA-like cavity has nearly completed the experimental evaluation, although the scope of the study is limited to those possible without using the beam. LL-cavity still has work to do in cross-examining the experiment and the calculation.
- On accelerating gradient: While progress has been made, world-wide, in circumventing the field emission issues, 9-cell cavities of both types at KEK have yet to see satisfactory gradient performance experimentally. The present situation does not allow us to base our choice decision on the gradient performance.
- On high-power couplers: Both coupler designs associated with TESLA-like and LL-cavities have demonstrated satisfactory performance in high-power RF operation. However, the one for LL-cavity has remaining concerns to resolve on its heat-load.
- On materials for the endplates: TESLA-like cavity has adopted Titanium, as established by the TESLA group. LL-cavity has adopted stainless steel and as a consequence a Nb-SUS transition has to be introduced. The long-term mechanical stability of this transition is yet to be experimentally established.

Details of relevant technical discussion are presented in the next section.

The assessment of the KEK LC office on the comparison between TESLA-like and TESLA-short cavities is as follows: The design of the TESLA-like cavity package aims to improve that of TESLA-short in the areas of mechanical sturdiness, simplified coupler structure, maintainability of tuners. They have a potential of being adopted as the ILC baseline for their design superiority in the future, although, at this point, these points are not yet widely established through experimental validation nor overall design optimization. It is the opinion of the LC office that the scheme of TESLA-like cavity highly merits further development, if it is guided to follow the Plug-compatibility requirements, in terms of positively contributing to the SRF technology development for ILC and of maintaining the momentum of present R&D efforts.

It has to be noted, however, the TELSA-like cavity scheme also still has numerous issues to resolve before implementing it at STF Phase2:

- Experimental validation of reduced Lorentz Detuning, as intended in the design, in comparison with TESLA-short.
- Experimental validation of HOM damping at the level similar to or better than TESLA-short.
- Experimental validation of high-gradient performance at the level similar to or better than TESLA-short.
- Argumentation of the superiority or validity of the input couplers with fixed coupling.
- Adoption of Plug-compatibility guidelines.
- Design of tuners that satisfy Plug-compatibility requirements.

The present design of TESLA-like cavity package, in certain aspects, is not compatible with the ILC baseline:

- Cavity shape
- Length and diameter of beam pipe
- Input coupler types

Furthermore, the relevant members of GDE have to reconcile the following issues:

- Flange and its sealing method
- Magnetic shield

As stated earlier, GDE is adopting the policy of facilitating development of better SRF components under the framework and restriction of Plug-compatibility requirements. Therefore, just because a certain component does not conform to the Baseline, it does not immediately follow that such a component is unsuited for ILC. Some components, such as tuners, do not have an established baseline definition. Relevant members from KEK must actively participate in the GDE discussion in developing the Plug-compatibility definitions, many of which still remain as open issues as of this writing.

Development of LL-cavity has been originally motivated by the desire for a higher accelerating gradient. The accelerating gradient (31.5MV/m) of present ILC design, while not solidly established technically, is known to sit substantially below the cost minimum from the standpoint of cost optimization. A potential benefit exists in maintaining development of LL-cavity from the standpoint of pursuing higher gradient into the future. As of Snowmass 2005, it was discussed that LL-cavity might become the baseline for the ILC phase-2 which was then considered as the 1TeV upgrade. These considerations support continued development of the LL-cavity package, although resource constraints do not permit it. In that case, scope-limited development only on the 9-cell cavities would be still meaningful. The Plug-compatibility requirements are, again, important boundary conditions to follow. However, they are not expected to be major constraints.

With the policies above, the KEK LC office intends to rapidly develop the new group organization at KEK, activity schedule including STF Phase1, commissioning and operation of the EP facility, and the JFY2008 budget. We note the increased role of KEK in the area of ILC SRF development. We wish to make this decision as the starting point for our renewed efforts.

3. Technical Comparison

In this section we summarize the reports from the two cavity groups and comments from the LC Office. The points of comparison are grouped as follows.

- Lorentz detuning and its correction
- HOM damping
- Accelerating gradient
- Integration with cryomodules
- Input couplers
- Safety regulation issues

It is noted that technical discussion in this section should be considered as draft at the present stage, since some numerical numbers are still being updated and analysis of data from STF Phase 0.5 still in progress, However, we believe there will be no essential modification that would change the conclusions.

（1） Lorentz Detuning (LD) and its Correction

(at 31.5MV/m under 2K)	TESLA like cavity		LL cavity	
questions	expectation	measurements	expectation	measurements
Margin of the load on piezo?	Needed stroke is estimated to be 1μm. The margin to take will be determined with internal/external drift taken into account.	Experiment was done on 2007.10-11. The static frequency change with piezo was ~150Hz (at 2K, tension 400kg, voltage range 0-500V). This corresponds to the stroke of 1.0 μm. Operation was confirmed up to the max voltage 1000V, which ensures max 2.0	The max piezo stroke is 4μm at 2K (160μm at 80K). The expected shrink under 31.5MV/m is 0.87μm, or adding the correction at equator, 1.23μm. Accordingly the margin against 4μm is a factor 3.2.	Cold test was done on 2008.2-3. The static frequency change was ~750Hz with the DC drive of 0-1000V at 2K.This corresponds to 2μm stroke.

		μm stroke, but hysteresis, non-reproducibility, and friction are seen.		
Required and expected Piezo lifetime?	The required piezo life is > 10^{10} pulses	No pulse data available. Life tests are needed.	The required piezo life is 2.2×10^{9} pulses, assuming 5Hz, 6000hrs/yr, 20yrs). If each piezo is fired 5 shots per pulse, this means 1.1×10^{10} shots. Lifetime of 1.5×10^{10} shots is needed if factor of x1.5 is allocated for margin. The tuner designed for lowered loads on piezo.	No life data available. Tests are needed.
Deformation of the cavity and the margin	The required piezo stroke is 1μm. The present system allows up to 2μm movement. The margin is factor 2.	Experiment in Oct-Nov.2007. The measured detuning at 18MV/m was 150Hz (1000μs flat-top). The extrapolation to 31.5MV/m gives 1.5μm. A simulation study is underway for more understanding of	Expected a cavity shrinkage of 3.45μm at 31.5MV/m in an early calculation, but this number is now known to be wrong, since a wrong density value (too small by factor 1/100) was assumed. An	Cold test done in Feb-Mar.2008. Observed detuning was 23 deg (153Hz) in the flat-top (Slow tuner, no offset 18MV/m). Simple extrapolation to 31.5 MV/m is 469Hz. The max correction reached this time was 460Hz with piezo

		LD. The value of the margin is to be reported later after studying the measurement method and the effects of the offset.	updated calculation is still missing.	4-cycle sine-wave voltage imposed. (Can be more, because the measurement sensitivity was saturated at 460Hz.) The present max amplitude is limited by the capacity of the power supply. The margin is expected to increase by reinforcing the power supply.
Influence of the cavity deformation	Influence on the field flatness, HOM, etc. is totally negligible. (The Deformation is only microns.)		Lorentz detuning deformation is ~1.3μm. No side effects are expected.	
Margin against the LLRF phase tolerance (+/-50Hz)	The target residual error is 100Hz (a margin of factor 2 is included)	Experiment done in Oct-Nov. 2007. The phase error at 18.2MV/m was less than 2 degrees (25Hz), with the noise level taken into account. A guess at 31.5MV/m is below 75Hz.	Will answer later.	Cold test done in Feb-Mar.2008. The observed residual error after piezo correction was within 2 deg (13Hz) at 17 MV/m in the absence of LLRF feedback. The contribution of the noise (observed microphonic of 6Hz) is thought to be large. The noise-to-detuning

				ratio is unknown at 31.5 MV/m. Simple extrapolation gives 7 deg (46Hz). However, it will be below 46Hz, if microphonic is independent of Eacc.
Correction scheme	By applying an offset voltage and a single shot on piezo for each machine pulse.		By applying an offset and resonant excitation of piezo shots (1-2 shots) for each machine pulse.	

Comments by the LC Office :

TESLA like Cavity :

The correction range is claimed to be larger than that of TESLA cavity by factor of 1.7 owing to the stiffer design of the endplates and the cavity body. The design principle, the method of estimation, and the logic of hardware design to realize them are considered to be reasonable. The measurements at 19MV/m at STF0.5 in November 2007 are not sufficient for determining the maximum correction range of this scheme. However, studies are under way on, the relation between the LD theory and measurements. The extrapolation to the STF2, where operation around 31MV/m-35MV/m is anticipated, is a future issue. Nonetheless, the technical uncertainty on the mechanical capability of the tuner is considered small. The reliability issues connected to the friction and hysteresis in long-term operation and the maintainability of the tuner system must be investigated.

LL Cavity :

The design is geared toward its usage in high field operation so that the piezo is placed at 80K and the detuning range covers up to 45MV/m. There is a sufficient margin when this cavity is operated at 31.5MV/m. Unfortunately, there was an error in the assumed parameters of the niobium material in the original estimation, and a correct evaluation has not yet completed. In addition, the evaluation of the correction scheme using the resonant excitation is not yet satisfactory. Thus, the comparison between the design intention and the measurement analysis of STF0.5 has some fundamental issues to resolve. The phase stability was confirmed to be in the range of 2 degrees at 18MV/m at STF0.5.

The reliability at 31.5MV/m and the possibility of pulse-wise stable correction are future issues.

（2） HOM damping performance

The status of the report to LC office (and to the LC-related members at KEK in general) about estimation and measurement of HOM damping is summarized as follows:.

	HOM damping for 1 cell cavities		HOM damping for 9 cell cavities	
	Calculation	Measurements with models or with actual cavities	Calculation	Measurements with models or with actual cavities
TESLA cavity (DESY)	?	?	Y	Y（actual cavity）
TESLA like cavity	Y	Y（copper model）	N	Y（actual cavity）
LL cavity	N	N	Y	N(actual cavity; data from new measurement still under analysis)

The answers from the two cavity groups to questions on the HOM damping performance from the LC office are summarized in the table as follows:

	TESLA like cavity		LL cavity	
Questions	Calculations (estimations)	Measurement (verifications)	Calculations (estimations)	Measurement (verifications)
Any issues of multipacting, breakdowns, heat up of HOM dampers?	MP and breakdowns are expected to process out easily. No pickup probes were used in the vertical CW test, to avoid heating problems.		HOM damper with new design will be used to solve the problems seen in the past.	Verification of the new design HOM damper has not been done yet.
Any issues of notch filter adjustment?	No problems.		The notch band width is 3MHz in design, while the frequency shift of the notch is less than 1MHz at low temperature. Thus,	No problem at 2K high power test.

			No problem.	
Any other problems?	Strength and high power capability of ceramics feed-through have to be addressed.		Analysis of HOM for traveling mode across the cavities is required.	
Plan of future development?	Rotational angle of the loop antenna is optimized with the STF phase 1.5 cavities. Study of feed-through will be done within 2-3 years.		After verifying the present design with STF phase 1 cavities, performance improvement of the performance will be studied toward STF phase 2.	

Comments from LC office:

TESLA like cavity：

LC office recognizes that the group claims the validity of the estimation method through a comparison between their single cell estimation and copper model measurement. The HOM of 9 cell cavity are estimated on the basis of estimation done with single cells. While no specific simulation exists for 9 cell cavities. However, measurements with a network analyzer and with a bead-pull method have been done for actual 9-cell cavities, and the results roughly satisfied the target. LC office considers that the method of evaluating the HOM damping performance is adequate. However, the group acknowledges an insufficient damping for the monopole mode. This issue has to be addressed through an improved design and experimental validation. LC office considers that it is desirable to perform an estimation HOM damping for 9 cell cavity in future.

LL cavity:

There is no HOM work for single cell LL cavity on both estimation and measurement. The estimations of HOM damping for 9 cell cavity have been done for an existing actual cavity and for the new design HOM couplers. However, measurements of the existing cavities have not been reported yet and the new design cavities are not yet completed. LC office considers that an initial study cycle of calculation, prototyping, measurement and validation is not yet completed for the HOM damping performance.

(3) Accelerating Gradient

The questions by the LC office and the responses from the two groups are summarized as follows:

	TESLA like cavity		LL cavity	
Questions	Calculation (Expectation)	Measurements	Calculation (Expectation)	Measurements
Gradient limit due to the shape	The preference on the cavity shape is affected by our technology level. If FE is the dominant issue, a shape with small Esp/Eacc would be better. If the quench at the equator dominates, a shape with small Hsp/Eacc is better. Issue of cavity drainage during rinsing will not be a problem whether TESLA-like or LL.		The gradient limit of L-band ~40MV/m is considered given by the theoretical limit of the critical magnetic field . Hence, cavities with small Hsp/Eac is advantageous. LL shape also has higher efficiency so that it can save operation power by 10-20%. The draining after rinsing caused no problem in our experience with single cell cavities.	50MV/m has been established with single-cell cavities. The best result with 9-cell is 36.5MV/m (w/o HOM couplers). At STF0.5, Ichiro old 9-cell cavity recorded 21.6MV/m (full pulse width 1.5ms)
Current limit of the gradient	FE is the limiting factor at TTF. The 20MV limit seen with 3 units of our cavities is suspected to originate from EBW joints.		Step-function-like X-ray generation hints MP. Its on-set behavior is not inconsistent with the empirical formula (comparison with T-mapping has not been done since TESLA single cell at DESY). The FE onset with our best single-cell cavities is Esp ~	

		over 94MV/m, corresponding to Eacc = 40MV/mfor 9-cell. Our 9-cell was limited by contamination of HPR pump. Hope better performance with degreasing. Difference due to the choice of the cavity shape is unlikely in this area of issues. On FE : While Esp/Eacc (ICHIRO 2.36, TESLA 2.0) is unfavorable, consider that a more dominant factor is the surface treatment technology.
Plan for achieving the gradient specification	Improve the quality of EBW joints with next cavities. Aim at >30MV/m with no CBP, if possible. Then, intend to try rinsing with H2O2 or detergent to address FE. Will be hard to judge which is more problematic out of rinsing and assembly processes.	It is needed to overcome MP and end-group FE for realizing the ideal gradient with 9-cell (observation from recent experiment). Remove sulfur to resolve the MP. The group will attempt improvement of rinsing effects by using detergent or ethanol, or by using CS_2. FE triggered by MP can be suppressed by removing sulfur. FE coming from insufficient rinsing will be solved by fresh EP. Sulfur is known to be a seed of FE and the measures for its removal is expected to be effective in reducing FE. In short, will try combination of fresh EP and ethanol rinsing for 9-cell surface treatment.
Time scale of the future plan	Try with next two cavities to be completed in March,2008.	Build 6 units of single-cell cavities of IES#5-type and conduct statistical studies of the method developed in the pilot study. This test will complete by Sep.2008. The highest priority for 9-cell is to exceed 31.5MV/m for the units to install in STF1 (LL group is planning 2 or more cavities) Expected completion date is Sep.2008, as per the installation schedule to STF1. S0 study will continue with the remaining

		9-cell cavities.

Comments by the LC Office :

TESLA like cavities

As the next step the improvement of EBW is mentioned for achieving beyond 20MV/m or 30MV/m. We understand this includes improvement of edge machining of half-cells and optimization of EBW parameters, etc. Concrete proposal in the near future works and testing procedure, however, is still under discussion. The proposed strategy for FE issues is to try detergent etc which is the current world trend. LC office feels that their strategy in pursuing or inventing new approaches to address the gradient issue is somewhat weak.

LL Cavity :

The LL group views that the gradient limitation comes from FE at the endgroup and from MP, rather than from the equator region,. Their list of planned actions includes sulfur removal and improvement of rinsing capability. For the gradient achievement in the STF2 they offer several ideas such as single-cell tests, surface analysis, and cleaning of the EP liquid. However, their list needs more specific and persuasive plans, for instance, on understanding the mechanism of having remnant sulfur, application of lessons learned from single-cell cases to 9-cell cavities, and others.

（4） Integration with Cryomodules

Comparison of compatibility issues associated with integration of cavities with cryomodules.:

TESLA-Like Cavity Group	LL Cavity Group
The group argues to establish the firm, common understandings of the component functionalities, including those from the installation and maintenance standpoint, which presently seems lacking,. Development of component compatibility guidelines should be done on that basis. The group feels that their design proposals can survive such discussion. ● As for the designs of tuner, Helium vessel, magnetic shield, cavity flanges and seals, their intention is to persuade other GDE members of the superior aspects of their design and attain the concurrence.. ● This group advocates a high-power coupler	Basic stance is to maintain maximum compatibility with DESY and FNAL designs. Compatibility with the TESLA design is broken only when the group feels that they have strong enough reasons. ● CC coupler is designed to be compatible with TTF3 coupler. But the sealing scheme based on MO flanges is incompatible. ● GDE does not have an established BC for the tuners, Their intention is to demonstrate good performance of their ball-screw tuner, thereby making it the BC. ● Ichiro cavity is compatible with TESLA-short cavity as far as the total length is concerned. But the beam pipe diameter and associated

with fixed coupling, which makes the assembly substantially easier. This is not BC, They feel that TTF3 or TTF5 coupler without cold bellows could be equally attractive.	flange-type are different. ● The material of the He jacket is SUS, and its connection with the beam pipe is done through a Nb/Cu/SUS transition made with HIP. Thus it is incompatible with the TESLA-type He jacket that is made of Ti. ● The layout of the magnetic shield is tightly related to the tuner configuration, and is dependent on of the choice of the tuner.

Comments by the LC office:

TESLA-Like Cavity:

The basic plan of this group is to demonstrate the superiority of TESLA-like cavity technology and to propose adoption of this design as one that meets plug-compatibility requirements. Consequently they are not necessarily pursuing full compatibility with the TESLA-short all the time. Assessment of the tuner part, in particular the increased mechanical sturdiness of the cavity package, is relatively well developed. What is critical would be to make a persuasive statement with specific data on the kind of benefits available from this design. While they are making more systematic surveys since early 2008, more qualitative and quantitative statements are needed in writing.

LL Cavity:

Basic stance of this group is to actively pursue compatibility with TESLA short. However, they are planning to claim superior designs in several main parts, such as sealing, tuner, flanges, jacket and magnetic shield, and in so doing they anticipate breaking some aspects of compatibilities. The specifics of their plans are somewhat unclear on how exactly to experimentally show the superiority of their scheme for each these items. (Similar ambiguities in the work strategies exist in case of the TESLA-like cavity group.) The only widely accepted notion for the superiority of LL cavity is its lower surface current, and its specific benefit has been demonstrated only in tests of single-cell cavities. Thus many of their ideas, which might be good, are not yet reaching the stage where revision of BC is sought with their demonstrated performance records.

(5) Compatibility of the input couplers:

On development of input couplers that support the ultimate performance of each cavity shape.

TESLA like cavity	LL cavity
The coupler and the cavity shape are separate issues.. The high power test of couplers at the test stand	● Sufficient performance to warrant successful operation of LL-shaped cavities has been demonstrated with the capacitive coupling

verified required performance. The rf processing of the installed coupler at STF Phase 0.5 proceeded flawlessly.	(CC) coupler for: high-power RF transmission (500kW/250kW in room/cold temperature environments), easy processing out of multipacting, smooth integration with the cryomodule, and tuning, both in room-temperature and low-temperature (Feb.-March, 2008) operations. ● Data has been collected for static and dynamic heat load, together with coupling performance during the cold test of Feb.-Mar. 2008. The coupling adjustability has bee shown to be nearly as per the design. The heat load and dynamic heat loss are under analysis. Strategies and design issues in cases of targeting operations at 35MV/m or 45MV/m: ● 35MV/m: Prove the superiority of CC coupler from TTF3 coupler, and propose it to replace BCD. We will stress the advantages of high through-put, low cost and short rf process time, which has been made possible by separating the metallic parts and the ceramics window parts. Operation at 2MW is a strong proof of high-power margin, obtained thanks to the TiN coating that reduces multipacting. ● 45MV/m: No additional cost exists to pay for a higher power transmission. Hence, no trade-off issues. The group intends to conduct a further study to confirm the required ceramics purity for ensuring long lifetime in higher power operation.

On question about the fixed coupling for the input couplers

TESLA like cavity	LL cavity
1) Benefits of the tunable coupling couplers: ● It can ensure a pulse flattop without using a	We will follow the international specification for the input coupler coupling tune-ability. Our

cavity voltage feedback. For instance, if a10% error exists in the coupling, the operational voltage need to by reduced by 0.5MV and the power divide ratio in the rf distribution needs to be revised, also. Since the pulse top is not flat in this case, it will be necessary to reduce voltage of the other cavities. (This can be recovered by using detuning control of the cavities, as well.) ● It can accommodate adjustments after installation into the cryomodule, or even sudden voltage changes during operation. (This can be also recovered by using detuning control.) 2) Tunable Coupling capability is covered by the input coupler and 3 stub tuner. Weak point of tunable input coupler is complicated installation procedure around cold-warm connecting flange and the initial cost of about 50M$. There may be a problem of standing wave in between cavity and 3 stub tuner. 3) Alternative procedure, cavity detuning control, is an important test item in the cryomodule test. It does not require any new hardware although there is loss of rf power efficiency.	input coupler is can adopt both fixed and tunable coupling.

Comments from LC office: TESLA like cavity:

LC office recognizes that the input coupler for TESLA like cavity achieved sufficient performance to feed the specified power into the cavity. It is necessary to prove the heat load performance and dynamic heat loss performance. The group advocates a fixed coupler design for advantages of cost and handling. However, LC office interprets that they would feel less strongly if a variable coupling coupler is realized without having to use bellows in the cold part of the system. The group is presently conducting a systematic surveys of how the ILC ML can be made to work with fixed couplers. The LC office wish to encourage the group to produce a full write-up on this subject.

LL cavity:

LC office recognizes that the input coupler for LL cavity achieved sufficient performance to feed the specified power into the cavity. It is necessary to prove the heat load performance and dynamic heat loss performance by the module test. In case of applying this coupler for 35MV/m operation, LC office understands that the group intends to prove and stress its high power capability and low cost. In case of applying it to 45MV/m operation, the group intends to prove its flawless performance. LC office feels that specific planning is required to conduct how these tasks are to be done in which timelines.

(6) Safety Regulation Issues:

Questions related to clearance of high pressure gas safety regulations

TESLA-Like Cavity Group	LL Cavity Group
● Analysis of the experimental results of Phase 0.5 and 1 is still necessary. However, they do not expect needs for fundamental design changes. ● Lightweight build, easy assembly and reduced cost will be pursued. However, these are not directly relevant to the clearance of High Pressure Gas Safety Regulations.	● Direction of the HOM polarization might be changed. However, since this is an issue outside the He jacket and does not affect the safety regulation aspect. ● Results from STF Phases 0.5 and 1 and analysis of gas safety issues might necessitate redesign of the helium vessel endplates or its material. The magnitude of the required work is unclear. ● If we are to implement the magnetic shield completely inside the helium vessel, the thickness of the end-half-cells will have to be increased. The optimization of the design through simulation will take roughly 1 month.

Comments from LC office:

TESLA-Like Cavity Group:

Their intention is to proceed with the application process to the High Pressure Gas Regulation for STF Phase2 without fundamental design changes.

LL Cavity Group:

They indicate possible revisions of the endplate material, the related component designs for the helium vessel, and the thickness of the end-group half cells. If these changes are found necessary, they need to be experimentally validated before STF Phase2, leading to a potential schedule delay