HLRF1 Background Notes 033106 RSL

<u>Status:</u>
1. Modulator: We have a good BCD model (in terms of being well known) for the modulator, a successful design that works, but not necessarily cost optimized. For cost modeling it has a set of components we can place in a WBS. An R&D program is in place to investigate an ACD as well as to evaluate two other designs: the SNS modulator, now operational at SLAC, and the Diversified Technologies modulator, due at the end of 2006. None of these will be available by June so none of them will be considered in the cost estimate.

2. Klystron: We have a BCD klystron that has not yet been successfully demonstrated. This is what we will use to gather cost estimates. There are three more or less equal competitive commercial designs, so presumably we will define the complete specs as thoroughly as possible and ask each vendor for quantity ("budgetary") quotations. We also have to identify all the peripheral parts needed for klystron operation and make sure they are included int eh WBS.

3. Waveguide Distribution: We have a model based on commercially available parts: Splitters, combiners, bends, straights, circulators, EH tuners. However, it is expensive and complicated and Chris Adolphsen feels we have a good chance to simplify it for the cost model. This will require a change in the BCD through the CCB headed by Nobu. We also, I believe, have to include the coupler for each of 24 cavities per klystron. Attached is the parts list I tried to develop into a set of quantities, from Chris Adophsen's original parts list, but I added actuators, monitors and the Nobody has reviewed this in detail; we need to do so.

1. Note by C. Adolphsen

At 11:04 06/03/30, Adolphsen, Chris wrote:

Remember the two items that are most needed for the civil work to proceed (i.e. item 4 below)

1) a clear statement of the power and cooling requirements for each rf unit (for the water, for example, you could state that you need a supply line that would provide x gpm of water at a pressure drop of y psi relative to the return line, and that this water will absorb z kW of power so its average temperature rise in degC will be roughly 4*z/x and you want the input water temperature to be stable to w degC over periods of hours. If you need more than one supply line, specify this same information for each line. How you connect to this line(s) to provide specific flows and pressure drops to the various rf components is the task of the rf group).

2) a plan for laying out the waveguide in the beam tunnel - this will require consultation with cryomodule and installation people.

Other useful items they need to know are

3) total heat loss to air - the estimate of ~ 1 kW per meter (20% of total power) given by Shigeki at Bangalore (slide 17 of his talk) seems very high and probably not practical.

4) number of penetrations required between tunnels (assume 36 cm diameter) based on number of cables and cable types

5) number of rf racks and their size

2. Response by S. Fukuda

I reply to the some parts of your remarks.
For (1), I will try to make a detail water line, and show it to the members of rf technical system to check it in a week.
(2) I had some comments about it in my memorandum attached with my previous mail. And I or somebody will show the plan of the layout.
(3) I will attach the revised version of Water/air cooling table. Basically it is not drastically improved (from 20% to 16%) because a big fraction of the load is come from the sub-unit racks. There are lot of assumptions for the efficiency of the power supply of the various modules, and the fraction of the loss to the real load and to end up to the air is not clear. The loss come from the motor drive for attenuator, piezo tuner etc. depends on how frequently operated they are, and this load is up to 2kW.
(4) For this points, I stressed that three waveguides in a penetration hole is not good configuration and it was stated in my memorandum attached with my previous mail. While if you make 3 penetration holes in each 36m period, it is OK to change the configuration among the proposed plans in anytime. Number of cables are necessary to re-count and cross-checked among the related groups.
(5) For numbers of rf racks and their size, I showed a plan in the attached excel sheet, but it is necessary to discuss about it with Chris Jensen who are drawing the general scheme shown in my Bangalore slide No. 18.
Best regards,

Shigeki

3. Issues Summary & Questions by S. Fukuda

RF Technical Systems Check Points (DRAFT of S. Fukuda)

(1) technical questions about the cost models, what information we have, what is missing

- Try to write down the exact and detail layout based on the BCD, then it is possible to do the cost estimation. Where is the undetermined parts and who decide the unspecified parts?
- **Most Cost Driver：ML**:

PDS: One of the cost driver is PDS and it is necessary to draw the detail layout based on the BCD.

Gas pressurizing: Use SF_6 or nitrogen gas, pressurizing or atmosphere.

Do we use waveguide windows? If there are pressurizing area and non-pressurized area in the same waveguide line, window is necessary. If use, how many windows do we use?

There is a possibility to use the WR770 from the klystron output to the hybrid to avoid the arcing inside (5MW line) and reduce the size to WR650 after the power divider (3.3MW line), then we can avoid the usage of the SF_6. It may be the CCB matter. (This is my personal preference).

What kind of flange do we use? From our experience, CPR650G/F is not appropriate from the leakage of rf and arcing. Klystron output flange of Thales we purchased is CPR650F and use the special gasket. DESY recommends the DR-14 flange.

We want to reduce the flange connection as possible as we can, and who determine it? We or area system? Relating to this items, combined waveguide components, for example, straight +directional coupler +bend.

Flexible waveguide is necessary to connect to the klystron windows. How about other places? If waveguide is cooled by water channel, it is not necessary to consider the thermal expansion and eliminate the flexible waveguide. How to make a water-channel? What kinds of fitting do we use? Maybe Swagelok ^{TM} is suitable.

The specification and structure of the wavegide attenuator (of semi-variable type or variable type) is not yet determined. How frequently do we need to adjust the attenuation? (area system)

For the configuration of the waveguide in the penetration hole, it is necessary to reconsider the layout that 3 waveguides go thru in a hole. It is difficult to make tighten all bolts and nuts and it leads to the arcing easily (from our recent experience of STF). I recommend that the waveguide connection in a penetration hole is performed by welding at the place where it installed. Otherwise once arcing occurs in that connection, we don't diagnose it without setting an arc sensor (expensive) and it is a great labor to fix it.

Linear power distribution (PDS) will be used in BCD, and the precision of the power dividing ratio and isolation are required from the tolerance how much we can allow the variation of the electric field in each cavity. If this tolerance is serious, the strict specification and inspection are necessary or adjustable mechanism to verify the directivity / isolation. If there are large variations of isolation, circulator is essentially inevitable. (In BCD, circulator is included in the design).

In BCD, 3-stub tuner or EH-tuner is to be used. It is necessary to know how frequently we do operate it or how much we can allow the change of the Qext. This information is come from Area system or global system.

For the waveguide configuration in the accelerator tunnel, I suppose that 3 waveguides immediately go down at the beam center direction from the positron transportation pipe and go thru under the cryomodule and connect to the linear power distribution system. It is necessary to draw the detail of the waveguide layout to count the numbers of the components.

Klystron: Specification of the horizontally mounted klystron should be determined.

- Configuration of the klystron window is necessary to specify. Waveguide size of the output waveguide and window (WR770 or WR650) are decided.
- Where and how many do we set the arc sensor to protect the failure of the klystron window? Maybe 2 arc sensors each of them looking at the klystron window. Are enough.
- It is necessary to make clear the procedure of the klystron replacement when klystron is failed. I image that the special tools to set up klystron is needed. It lifts up klystron and takes out from the klystron position and put it on the carrier of the klystron. Simple adjustable (up and down, tilt and so on) mechanism to fit to the waveguide system is necessary for the girder. From that view point, FNAL drawing of the klystron and waveguide layout is not comfortable.
- For klystron socket, independent socket tank is desirable separated from the pulse transformer tank. Basically the labor work involving the oil handling in the service tunnel should be avoided as possible as we can. For the co-axial cable connection and the HV terminal, ether of 140kV cable terminator of Isolation Product (which is used in J-PARC) or SNS-type cable terminator can be possibly used. For the survey of the reliability for the cable usage should be performed.
- Mechanism to handle the oil expansion is necessary. Expensive type employing bellows or cheap type using rubber balloon with a proper stopper mechanism can be used.

Pulse transformer and tank:

- Is it necessary to have a special design to reduce the leakage inductance of the pulse transformer? The pulse transformer made by ABB in DESY is very compact one.
- Is it necessary to have a special design to decrease the number of the cores? What type of the voltage monitor is cheap? What type and how many current transformer do we need? Two transformers, one for interlock and another for diagnosis is desirable.
- If klystron socket tank is separated, where does the heater transformer locate in the socket tank or pule transformer tank?
- How to judge the necessity of oil replacement and how to proceed if necessary? Associating to this issue, how do we replace the pulse transformer tank if it has a failure or a necessity of oil exchange? It is the heaviest element in the components which is used in the RF systems.
- Oil expansion tank or some mechanisms same as the klystron socket tank are needed.

Modulator:

- For the size of the modulator, there are several types such as the FNAL type, PPT type and so on. Especially, DC power supply was very compact for the PPT modulator. I have some slides taken when I visited in Feb. 28 of 2005.

What is the general concepts for modulator maintenance? For example, modulator in the KEKB injector linac comprised of the many units of modules, which are easily replaced similar like the plug-in module way. Big elements such as the transformers are replaceable, also. (Area system should show the guide line).

Easy replacement of the possible troublesome components such as the IGBT, diodes and so on is carefully designed.

Modulator interlock, protection etc.:

For this issue, there are no fully discussion and no unified idea, and we should quickly discuss about the necessary issues. What kind and how many interlocks do we need and how highly do they allocate to the level of interlock? How do we link to the associated interlock system relating to the LLRF and HLRF. Generally interlocks are handled in the different category for the RF related items.

In KEK, each sub-unit rack related to the modulator has PLC, and it handles the interlock, operational trend history, failure history recording and so on. This PLC communicates with higher computer system thru the network and all date are accumulated in the central data station.

This kind of system is highly depending on the each aerial system and it is necessary to communicate each other.

- **Positron Source and electron source**:

There are the places that the density of the modulators in the service tunnel is high. For example, in NC positron capture section, 5 units are located in the length of 15.44m and in the pre-accelerator section 8 units are in the 34.4m. If we scatter these units in the equal interval in the service tunnel, waveguide length is not unique to the cavity structures and each cavity section has a different power. How degree is the variation of the power allowed? (Area system) And we should try to draw the layout to determine the possible position and the interval for the modulators and klystrons.

Detail RF specifications are shown from the area systems.

- **RTML**:

RF for this section, requirement for the phase and amplitude tolerance are very tight. It should be cleared that this kind of severe requests are covered by LLRF or not? If not, it should be shown to the effects to the modulator, klystron and waveguide system from the area systems.

- **DR**:

It is necessary to have an agreement with the CF group about the RF modulator and klystron installing area. After the decision of the area, we start to draw the layout of the RF systems. It depends on the area size, the height and the structure, but it may be necessary to develop the horizontally mounted 650-MHz klystron.

For the klystrons, is it necessary to have a high efficiency similar like the mbk or is it just OK for the efficiency similar as the KEKB 500-MHz klystron? (Mbk development is necessary or not).

For the rf system, is it necessary to have a backup(or stand-by) klystron in the DR station? There are some places where the stand-by klystrons are equipped. It should be shown about this requirement form the area systems.

Layout and configuration of the modulators and waveguide systems are also established similar like the ML area's work, and then we can break down the numbers of the components and have a cost estimation.

(2) To make up a list for the various components as best you can

I will try to do this work.

(3) to put together a timeline as to when we have to get costs done in order to be ready at Vancouver; and who is going to actually be responsible.

In Asian area, I will be responsible for doing the cost estimation. Other responsible person I expected, are Tesuo Shidara, Mitsuo Akemoto and Leader of the KEKB-RF group. I am afraid Sergy Kazakov may be not so effective for cost estimation except for the items for the Russian products. (I expect him to the ACD matters on PDS and R&D). I will expect Nam in Korea and Purushottam Shrivastava in India. I will try to look for the Chinese guy for this cost estimation work. Maybe Tetsu Shidara will contact with China. For the modulator, and klystron, we need to collaborate with the vendors taking after the experiences of STF construction. For waveguide system cost, it is necessary to make clear about the strategy how to precede the procurement. As somebody in the meeting of Bangalore told, usual waveguide components are similar as the water cooling pipes and not the highly technical products, and should be cheap. How to separate the products, which include high-tech elements and which don't, are important. Or there is an another way to determine how to make a prototype at first and to break down to the mass production model. I am not sure we can do this up to Vancouver, but cost estimation will be strongly depending on how we do proceed about the things mention above.

(4) a complication is that different regions may come up with different cost models but we have to go to Vancouver with one model, time estimates for labor, and probably dollar costs for M&S.

This is really difficult points. It is necessary to discuss it to make the reasonable and unified cost estimation model.