BROOKHAVEN NATIONAL LABORATORY
Alternating Gradient Synchrotron Department
MEMORANDUM

DATE: February 23, 1999

TO: H. Kirk

FROM: V. LoDestro

SUBJECT: LBL Trip Report, 70 MHz Amplifier System

During the afternoon session of Feb. 18th, the Mu-Collider Low Frequency RF meeting I meet with Don Howard. We inspected the 70 MHz 8973 amplifiers and support equipment. Most of my concerns as expressed in my review of Don Howard's October report have been reconciled. The essential equipment including the final amplifier stations, driver stages, most support and control equipment remains in tack at the Hilac site. In addition RF cooling water, cavity vacuum and tunnel security systems remain operational. This will greatly facilitate the use of the Hilac cavity as our test load.

It appears that four phased locked amplifier chains operating directly into one of the bunch rotator cavities offer a high probability, at minimum cost, to secure 4 – 6 Mwatts of 70 MHz peak power. I now feel that making operational one amplifier chain, developing a higher power tune and testing all available tubes into the LBL Hilac is the best way to achieve this requirement.

The following is a list major tasks and details based on Don Howard's report and our review which will need to be addressed to complete the testing at LBL and construction at BNL:

- Assembly of a three rack system for the LLRF controls, LLRF amplifiers, tracking oscillator and some bias and plate PS for the intermediate RF stages. These racks will return to BNL after the testing and serve as the model for the remaining amplifier systems to be assembled. (some rack equipment my be dedicated to the test only)
- The plate power supply capacitor bank will have to be enlarged to deliver the extra plate current required during the RF pulse to reach 1.5 MW. (design for 100 amps for 120 usec) This PS and Cap Bank will not be available to return to BNL.
- The amplifier has two crowbar systems, the RF Crowbar and the Plate Cap Bank Crowbar. The RF crowbar triggers a spark plug in the cavity, dumping the cavity stored energy into the arc when a limited 8973 plate arc is sensed. The Plate Bank Crowbar fires an ignitron taking the stored energy in the bank to ground if a fault plate current reaches a higher threshold. Both these Crowbar systems are available for the LBL testing, requiring only a Plate current sensing and logic circuit to be built. The RF crowbar electronics will come with the amplifier cart, however a new plate capacitor bank crowbar system will have to be constructed along with the capacitor bank and power supply at BNL.
- The output coax from the amplifier to the cavity is a ½ wave resonant line. The amplifier and loop are at voltage nodes with a current node in the center. LBL uses the current node

point to introduce water cooling for the coax center conductor and RF feedloop. However given our low duty cycle we will not require this cooling and can build our cavity loop at any ½ wave multiple of the amplifier output coupling. The coax is not a standard EIA design so we will need to design an adapter to 6" coax to mount our feedloop. We could also mount the amplifier ½ wave away from the cavity loop, as the Hilac and just use the existing coax through a shielding wall.

- All the 8973's are supplied with ion pumps. These pumps have all been disconnected. I recommend we start these pumps at all the RF stations as well as the four spare tubes.
- The Hilac Accelerator Tunnel is still a fairly well secured area. All tests could be done with a minimum impact to other LBL activities in the facility. A night shift conditioning schedule could be arranged.
- A cavity cooling system would not be required because of our low duty cycle. A tracking oscillator would be used as the LLRF source locked to the tank resonance. The frequency would remain within the bandwidth of the amplifier chain.
- The cavity feedloops are adjustable so we could match to a range of impedances.
- The 8973 filaments will be powered form a 500 amp EMI PS. A rectifier bank is built into the amplifier cart powered from a remote autotransformer. These autotransformers would be available to BNL, however I recommend we use DC PSs.
- To retard cavity breakdown a magnetic field is required in the cavity driftube quadrupoles. Multipactoring electrons in the accelerating gaps are swept away by this field. The original Quad Pulsed Power Supplies may not be required; a small DC current may be all that's required. However some of the quadrupoles may be shorted. We should locate any shorted quads as soon as possible.
- I recommended we perform the tests using an amplifier station for Tank 2. Tank 2 required two amplifiers to fully excite it. Therefore we could push the power of a single amplifier without reaching the sparking limit of Tank 2. The feedloop should handle the extra power.

In Conclusion:

- The equipment is in better condition than I expected.
- Testing at LBL is highly recommended and the use of the Hilac cavity as a load in now preferred.
- Performing these tests at LBL will give BNL a big advantage in reassembly at BNL.
- The major BNL effort will be in the design of the plate power supply, cap bank, crowbar system and RF feedloop.
- Start 8973 vacuum ion pumps and test for shorted quads in Tank 2, ASAP!
- It appears this may be the lowest cost option for 6 MW's of 70 MHz RF.

On a second issue, I am familiar with the Thomson Diacrode TH628 presented at this meeting as a possible tube for high power VHF RF. LANL LANSCE has purchased a tube and is presently designing a 200 MHz amplifier cavity. The tube will operate with DC plate voltage and modulated LLRF for gain control. The tube and cavity will also have application at the AGS Linac. It has been suggested that BNL collaborate in the development of this new RF system. Perhaps now is a good time to peruse this collaboration again. The Linac and Mu-Collider would both benefit from pushing the peak power limits from the existing 3.2 Mwatts. (3.5Mw is likely 4.0 Mw is possible at low duty) A lower frequency amplifier cavity

for a bunch rotator cavity above 100 MHz may be possible if we work with Carl Friedrichs of LANSCE.

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Cc: J. Alessi
Attachments: 8973 RF System Photos \ Hilac Facility