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INFORMAL REPORT

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The cavity design for the large ring of the proposed synchrotron light source is the one which is being considered in this report. It represents the worst case situation in all respects so that a similar design for the small ring will face no problems.

Basic requirements are that the cavity provide a peak gap voltage of up to 500 KV at a frequency of 53.52 MHz. Sufficient tuning range must be provided to allow for the reactive detuning of the beam and also thermal changes. Provisions for phase and amplitude control of two cavities operating together must also be available and attention must be given to possible higher order mode excitation at frequencies which are harmonically related to the operating frequency and also to some degree the 2.23 MHz rotation frequency. There are also space limitations imposed by the chosen magnet lattice and the need for a beam wiggler in the same straight section as the rf cavity. The practical upper limits of cavity diameter and length are about 1.25 m and 1.7 m respectively.

Stability Criterion

K. W. Robinson has described beam-RF instabilities related to the tuning and coupling conditions of the rf cavity with the resultant inequality for stability being

$$0 < \sin 2\varphi_y < 2 \frac{V_s}{V_B} \cos \varphi_s$$

where φ_y is the phase angle of the cavity admittance, V_s the gap voltage due to the rf source, V_B that due to the beam and φ_s the synchronous phase angle. Rena Chasman has calculated the beam power requirement for a synchronous phase angle of 22.5 degrees and 1 A beam current at 2 GeV to be 330 KW. This gives an upper limit to the allowable cavity shunt resistance of about 3 MΩ.

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Power and Voltage Considerations

Although the stability criterion requires that the shunt resistance be low it is not desirable to have too low a value as the cavity power dissipation becomes excessive. A shunt resistance of $0.5 \text{ M}\Omega$ would require 250 KW of rf cavity dissipation power for a peak gap voltage of 500 KV so this is certainly a practical lower limit for shunt resistance. The maximum allowable electric field strength is also important as this determines the allowable gap dimension and cavity length and diameter. At 50 MHz the maximum safe electric field strength is about 8 MV/m.

Design Choices

At the chosen frequency it quickly becomes evident that a reentrant type of cavity such as a double quarter-wave coaxial line is necessary in order to achieve the desired shunt impedance and gap voltage. However the simple configuration shown in Figure 1 for a practical gap dimension of about 20 cm requires cavity length and/or diameter which exceeds the allowable limits. In order to reduce the cavity dimensions it is necessary to load the cavity gap with a large capacitive plate similar to that of the SLAC cavity used in SPEAR 1 (Figure 2). The SLAC design was calculated using SUPERFISH and it was found that the peak surface fields at the extreme radius of the capacitive plate would be greater than 12 MV/m for a gap voltage of 500 KV. This, coupled with the fact that the tuning arrangement used further distorts the field in that region, probably explains the difficulty they experienced with breakdown at gap voltages in the region of 350-400 KV.

By increasing the radii of curvature of the capacitive plate and hence its thickness we arrive at the design shown in Figure 3 where the maximum surface field gradient is 4 MV/m for a gap voltage of 500 KV. The cavity length and diameter are approximately 1.3 m and 1 m for this configuration with a gap size of 23 cm. For an aluminum cavity of this type the shunt resistance is between 1.5 and $1.7 \text{ M}\Omega$ so that for a peak gap voltage of 500 KV between 75 and 85 KW of cavity excitation power is required. The actual design voltage is about 400 KV requiring about 45 to 55 KW of power. The total power required including beam power is therefore between 375 KW and 400 KW which is consistent with the available power tube capabilities utilizing a single drive system per cavity.

Input Coupling and Tuning

The input coupling system will be via a water cooled loop coupled to a 9" coaxial transmission line and ceramic vacuum window, situated close to one end of

the cavity. The coupling will be fixed and designed to match to the maximum beam loaded condition.

Tuning may be achieved either by a rotating paddle or metal ring acting on the maximum magnetic field near the outer or inner conductor at the end wall. Other tuning schemes may also be tried.

When the cavity dimensions and tuner ranges have been finalized, using the SUPERFISH program, higher order mode computations will be made and suitable provisions made for changing these mode frequencies if necessary.

FIGURE 1. Simple Coaxial Reentrant Cavity

FIGURE 2. SPEAR I Cavity with Tuner

FIGURE 3. Proposed Cavity Design for NSLS