THE RF GUN DEVELOPMENT AT SRRC

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The rf gun technology is of increasing interest due to its promising ability of producing high-brightness electron beams. Therefore it is a very attractive injector for any accelerator system demanding high current or low emittance beams, such as free electron lasers, linear colliders and other advanced accelerator applications. It is desirable to develop this technology at SRRC for future applications. The prototype cavities were fabricated and the low power level rf measurements were performed. The preliminary results are presented.

I. INTRODUCTION

Since the invention of the rf gun around mid eighties [1,2], it has attracted more than thirty research projects worldwide [3]. The promise of the photocathode rf gun to offer a high-brightness electron source has made many applications possible.

We plan to develop this technology at the Synchrotron Radiation Research Center (SRRC). Since the S-band rf gun system of the type developed by the Brookhaven National Laboratory (BNL) [4] has been widely used in many places, and the linac frequency of the SRRC booster synchrotron is also around 3 GHz, we decided to investigate this system as a start. The first step was to scale the frequency from 2856 MHz of the BNL gun up to around 3 GHz of our linac frequency by using the URMEL code. For the purpose of a quick start, we sent the very primitive design for the fabrication of a prototype copper cavity without further optimization yet. We would like to gain more experiences for tuning this one and a half cell structure through the cold tests first. On the other hand, we also fabricated an L-band (1.3 GHz) rf gun prototype cavity of the same type used in the AWA project [5]. We made low level rf power measurements for both gun cavities using the HP8510C network analyzer.

Recently, we are also involved in the collaboration for the X-band (8568 MHz) photoinjector project [6]. A prototype copper cavity will be manufactured very soon.

II. EXPERIMENTAL SETUP

The main experiment to be performed is to measure the electric field distribution along the center axis of the cavity in the longitudinal direction. This is accomplished by the frequency perturbation method, usually called the bead-pull measurement. The whole setup for the bead-pull measurement of the S-band gun cavity is shown in Fig. 1. A copper bead with 3.98 mm diameter was used as the perturbation object. A fishing string passing a 1 mm diameter hole in the center of the cathode plug, the copper bead and the end cover plate of the cavity was laid on the V-shaped grooves of the pulleys. One of the pulley was connected to a driving motor. A supporting stand was made to accommodate the gun cavity for the bead-pull measurement. The central frame which is detachable from the supporting stand is used to hold all parts of the cavity and waveguide tightly together. For different gun cavities, we only need to replace the central frame.

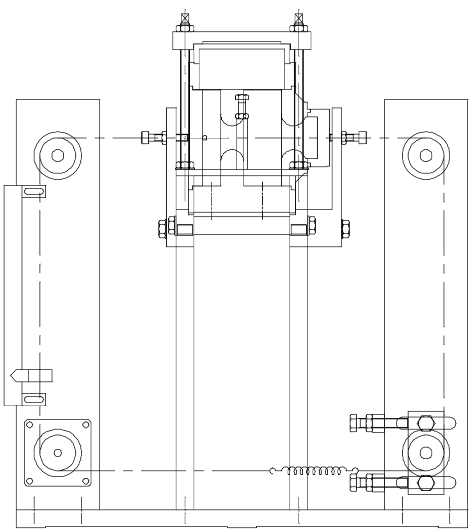

Figure 1. Assembly drawing for bead-pull measurement

We have not installed the tuner on each cell yet. At present we only used the cathode plug for tuning purpose. The cathode plug is made as big as 6 cm in diameter to avoid the high field area for the rf choke joint surrounding the cathode. We hope this will reduce the arcing around the choke joint under high power operation. The cathode surface will be flush with the cavity inner surface and be held still in full power operation. The tuning of field balance will be achieved through the tuner on each cell. The resonant frequency of the structure will be controlled by the cooling temperature. The S-band waveguide is shorted on one end and the other end is connected to the network analyzer through the WR284 waveguide to coax adapter. We used a sliding brass block of 3 cm thick to find the best coupling position for the shorting plate.

In order to build the cooling channel inside the cavity instead of just braze it on the outer surface, we modified the outer shape of the AWA drive gun cavity to be rectangular for easier machining. Figure 2 shows the outlook of the cooling channel.

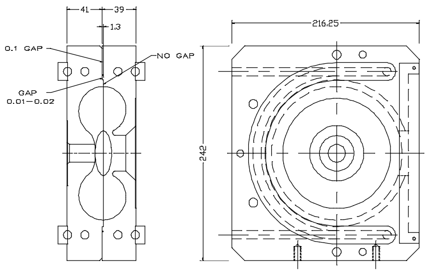

Figure 2. The cooling channel for the AWA dive gun cavity.

III. PRELIMINARY RESULTS

Before the bead-pull measurement, we first adjusted the sliding block to search the maximum rf power coupling position for the shorting plate. The S-band cavity resonant frequency was around 2922 MHz. It was found a shorting plate located at a distance of 11.5 cm from the center of the coupling hole gives the best coupling. This distance is very close to 3/4 guide wavelength which is 11.78 cm.

A complete turn of the cathode for the S-band cavity is made to be 1 mm. Therefore we are able to measure the frequencies of π-mode and 0-mode as a function of the cathode position. The results are shown in Fig. 3. We did notice the same phenomenon as observed in BNL and UCLA. The frequencies of both π-mode and 0-mode approach each other when the cathode surface get closer to be flush with the cavity inner surface and then turn into one another when the cathode is away from the inner surface of the cavity.

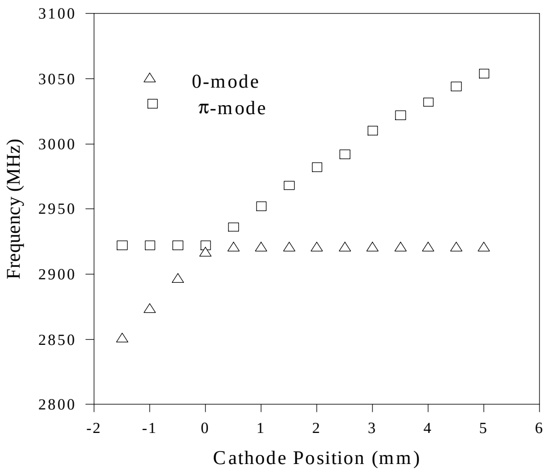

Figure 3: Frequencies vs. cathode position

The tuning for the field balance on both cells of the cavity is very sensitive to the cathode position. The field balance position is around where both π-mode and 0-mode frequencies approach each other. Figure 4 shows a bead-pull measurement result where the ratio of the maximum field amplitude in the first cell to second full cell is around 0.87. The cathode surface is at 0.13 mm outward from the cavity inner surface for this case.

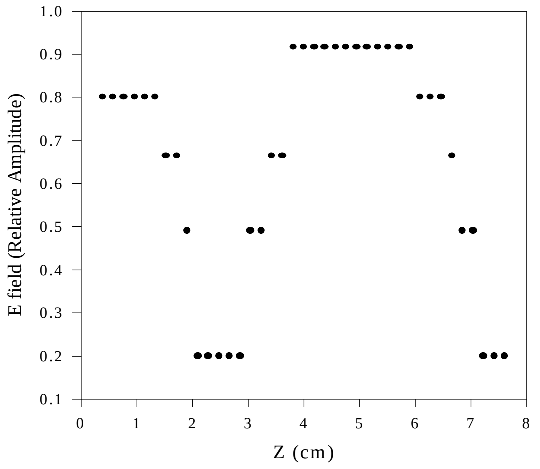

Figure 4: E-field distribution along the axis

We also performed the bead-pull measurement for the AWA drive gun cavity. We compared the measurement results with the URMEL prediction [7] by normalizing both field amplitudes to be the same around the cathode surface. Figure 5 shows the consistency between URMEL calculation and the measurement.

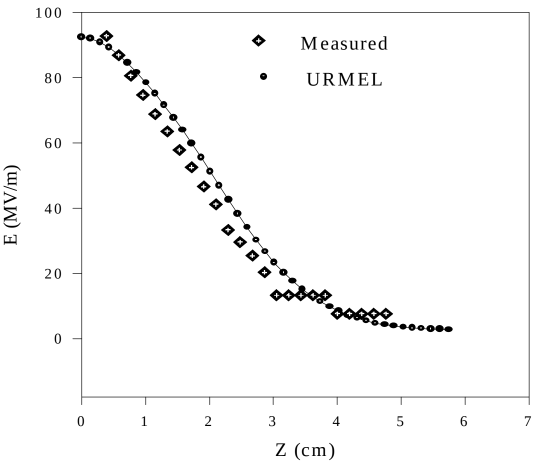

Figure 5: E-field distribution on axis.

The quality factor for the 1.3 GHz AWA gun cavity was measured to be around 12827 which is very close to what they measured before [7].

IV. SUMMARY

We performed some cold tests for both 3 GHz and 1.3 GHz rf gun cavity. The preliminary results show good agreements with URMEL prediction and previous works performed at other places. But it's only a beginning of a more complete investigation. After that we will begin to send the cavity for a vacuum furnace brazing. Also as mentioned before, the X-band prototype cavity will be fabricated in the near future.

V. ACKNOWLEDGMENTS

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