Date: December 3rd, 2015

To: RSC, E. Wang, Q. Wu, S. Pontieri,

From: D. Beavis

Subject: Operation of the 1.3 GHz gun in SVTF

The review of the SVTF blockhouse occurred in 2009\(^1\). The review was conducted with the 1.3 GHz gun parameters, but the gun was never operated in the blockhouse. Until now only a few cavities have been tested in the blockhouse. The gun is now ready to be tested inside the blockhouse and will be the first beam generating device tested in the blockhouse. It was decided to check a few issues before the gun is operated inside the blockhouse.

E. Wang has provided a technical note that documents\(^2\) the quenching of the cavity at low power along with an analysis of the reflected power of the cavity. These details provide a technical basis for power in the cavity being limited to much less than the power supply rating. The 10 Watts of power used in the minutes of 2009 should be more than adequate.

The shield roof was reported in the minutes as a single layer of concrete 28 inches thick, but before any operation occurred with x-ray sources was upgraded to two layers for a total of 56 inches of concrete. After recent inspection of the concrete seams some steel shims were added to seams on the north shield wall.

The power supply was examined by RF engineers and they recommend\(^3\) that a maximum rating of 200 Watts be used. The power supply should have a label that indicates the correct maximum power. The power supply appears to be in good operating condition\(^4\). The quenching of the cavity is expected to occur at much lower power (about 5 Watts) so there is no expected change to the potential radiation conditions outside the SVTF blockhouse.

The initial analysis estimated 100-200 mрадs/hr outside the ports in the shielding for 10 Watts at 1 MeV. The port exits are shadowed on the outside by concrete and barriers prevent access to the region of elevated radiation levels. These areas should be surveys when the gun is operated along with the cracks along the shielding by RCTs.

Based on the information discussed above I sign the RSC check-off list that the review of the power supply is complete.

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\(^1\) RSC Minutes of March 17, 2009; [http://www.c-ad.bnl.gov/esfd/RSC/Minutes/3_17_09Minutes.pdf](http://www.c-ad.bnl.gov/esfd/RSC/Minutes/3_17_09Minutes.pdf)
\(^2\) This has been provided before.
\(^3\) A. Zaltsman e-mail to E. Wang, Nov. 30, 2015.
\(^4\) S. Polizzo e-mail to E. Wang and A. Zaltsman, Nov. 30, 2015
The following note was provided by E. Wang on Nov. 18, 2015:

RF solid-state amplifier for 1.3GHz gun memo
Erdong Wang

- The 1.3GHz RF amplifier maximum output is 150W which measured by T. Seda. According to Ilan Ben-Zvi and Dmitry Kayran experiences, this amplifier maximum output is always 150W when it came from vendor. The label outside of the amplifier is wrong. We didn’t modify any of the internal circuits.
- The gun with the cathode plug was tested at JLab from 2011 to 2012. It shows the maximum peak field on the cathode is 55MV/m. Above that the gun will be quench. The radiation on the maximum gradient is 100mR/hr measured at JLab vertical test facility.

- The beam test and required RF power specific numbers are list in the table 1.

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<table>
<thead>
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<tbody>
<tr>
<td>Field emission I</td>
<td>160nA</td>
</tr>
<tr>
<td>Cathode field</td>
<td>30MV/m</td>
</tr>
<tr>
<td>Gun gap voltage</td>
<td>14MV/m</td>
</tr>
<tr>
<td>Beam energy</td>
<td>800keV</td>
</tr>
<tr>
<td>Beam power</td>
<td>0.13W</td>
</tr>
<tr>
<td>Peak current</td>
<td>0.012mA</td>
</tr>
<tr>
<td>Storage energy</td>
<td>0.67 J</td>
</tr>
<tr>
<td>Q0</td>
<td>7e9</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>0.13W</td>
</tr>
</tbody>
</table>
If the input power is higher 2.4W, the gun will quench and change to normal conducting state.

- Gun circuits set up

<table>
<thead>
<tr>
<th>Maximum power gun can hold</th>
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<tr>
<td>Q0</td>
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<td>Power dissipation</td>
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If the input power is higher 2.4W, the gun will quench and change to normal conducting state.

- Input and reflection power calculation

The port 1 is input power coupler whose Qext is preset to 2e8 and port 2 is pick up coupler whose Qext is preset to 3e11. The reflection power from port 1 will reflect to circulator and get into the 500W power terminator.

- When Gun in super conducting state, The maximum Ploss+Pbeam is 2.5W (from table 1), Pe is 12 W. So the $\beta_s$ is equal to 4.8. In case of over coupling, the coupling parameter could be wrien as

$$\beta = \frac{1+\Gamma}{1-\Gamma}$$

where $\Gamma$ is reflection factor. We can get the reflection factor is 0.65.

$$\Gamma = \frac{P_r}{P_i}$$

Pr/Pi is equal to 0.42 which means 42% power will be reflected and dumped into the terminator.

- In the case of quench, the Q0 drop to 5000 approximately (typically 3000~10000). The cavity wall dispassion power is much larger than beam power loss. Based on eqn 1, the coupling parameter is 0.000025. Then we can calculate the reflection factor by eqn 2~3 is 0.99995. The Pr/Pi is equal
to 0.9999 which means 99.99% of power will reflect back into the terminator.

In worse case, 150W power output from amplifier, only 0.01% power will be put into the gun, approximately about 0.015W into the gun.

- Conclusion
  When the power supplier forward full power (150W) to the gun, the gun will quench and change to normal conducting state. Once it happen, almost all the power (99.99%) will reflect from gun and get into the 500W terminator.