AN UPDATE ON THE STUDY OF HIGH-GRADIENT ELLIPTICAL SRF CAVITIES AT 805 MHZ FOR PROTON AND OTHER APPLICATIONS*


Abstract
An update on the study of 805 MHz elliptical SRF cavities that have been optimized for high gradient will be presented. An optimized cell shape, which is still appropriate for easy high pressure water rinsing, has been designed with the ratios of peak magnetic and electric fields to accelerating gradient being 3.75 mT/(MV/m) and 1.82, respectively. A total of 3 single-cell cavities have been fabricated. Two of the 3 cavities have been tested so far. The second cavity achieved an $E_{acc}$ of ~50 MV/m at $Q_0$ of 1.4 x $10^{10}$. This result demonstrates that 805 MHz cavities can, in principle, achieve as high as, or could even be better than, 1.3 GHz high-gradient cavities.

INTRODUCTION
SRF cavities have been successfully used for various applications [1]. Regarding the accelerating gradient ($E_{acc}$), a handful of single-cell cavities have achieved >50 MV/m [2, 3], close to the limit of Nb SRF cavities due to Nb’s presumed RF critical magnetic field of ~200 mT at 0 K. Also, 1.3 GHz 9-cell cavities have achieved up to 42-44 MV/m [4, 5]. While most of the high-gradient cavity research is focused at 1.3 GHz owing to the future International Linear Collider (ILC) project, we have been studying the possibility of high gradient SRF cavities at 805 MHz for applications that require, or benefit from, high gradients at 805 MHz.

DESIGN, FABRICATION AND SURFACE TREATMENT
Based on the successes at other institutions in achieving >50 MV/m with so-called low-loss (LL) and re-entrant (RE) shape cavities [6], cavity shape optimizations have been performed at LANL. The detailed optimized parameters are shown in Ref. [7]. Among the 3 designed shapes, we decided to fabricate “standard” shape, which, in terms of the cross sectional view, looks like somewhere between TESLA-TTF shape and LL shape as shown in Fig. 1. This shape is more suited for cleaning with high-pressure water rinsing due to the ease of draining.

Half cells were deep drawn from fine grain RRR>250 Nb sheets and electron beam welded at TJNAF. Three single-cell cavities were fabricated and 2 of them have been tested so far. The detailed result of the first cavity was reported in Ref. [7]. Despite a failed chemical polishing, the result was surprisingly good, i.e., $E_{acc}$ ~ 22.5 MV/m limited by available power.

The second and third cavities underwent buffered chemical polishing (BCP) and high-pressure water rinsing (HPR) at TJNAF since the HPR facility at LANL was temporarily unavailable. The cavities were then transported to LANL with a plastic cap on each beam pipe port. At LANL, the input and pick-up power couplers were attached in a class-100 clean room. The input power coupler was a moveable type and connected to the bottom beam pipe with a vacuum line as shown in Fig. 2.

Figure 1: A comparison between TESLA shape and new “standard” design. The shapes have been scaled to the same cell length for comparison.

Figure 2: The 805 MHz cavity with a moveable coupler and a vacuum line attached at the bottom.

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COMPARISON WITH OTHER HIGH-GRADIENT CAVITIES

Table 1 shows the comparison of various parameters including surface treatment with 2 high-gradient cavities. They also would like to thank G. Eremeev and P. Kneisel of TJNAF for their suggestions.

### Table 1: Comparison of the KEK, Cornell and LANL Single-cell Cavities That Showed Remarkably High Gradients

<table>
<thead>
<tr>
<th>Parameter</th>
<th>KEK Low-loss Shape [3, 8]</th>
<th>Cornell Ret-entrant Shape [2, 9]</th>
<th>LANL New “standard” Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resonant frequency [MHz]</td>
<td>1300</td>
<td>1300</td>
<td>805</td>
</tr>
<tr>
<td>Beam pipe inner diameter [mm]</td>
<td>61</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>$E_{pk}/E_{acc}$</td>
<td>2.02</td>
<td>2.12</td>
<td>1.82</td>
</tr>
<tr>
<td>$B_{pk}/E_{acc}$ [mT/(MV/m)]</td>
<td>3.56</td>
<td>3.50</td>
<td>3.75</td>
</tr>
<tr>
<td>R/Q [ohm]</td>
<td>138</td>
<td>140</td>
<td>130</td>
</tr>
<tr>
<td>Geometrical factor [ohm]</td>
<td>285</td>
<td>283</td>
<td>279</td>
</tr>
<tr>
<td>Measurement temperature [K]</td>
<td>2</td>
<td>2</td>
<td>2.0-2.1</td>
</tr>
<tr>
<td>Maximum $E_{acc}$ [MV/m]</td>
<td>53.5</td>
<td>59</td>
<td>50</td>
</tr>
<tr>
<td>Maximum $E_{pk}$ [MV/m]</td>
<td>108</td>
<td>125</td>
<td>91</td>
</tr>
<tr>
<td>Maximum $B_{pk}$ [mT]</td>
<td>190</td>
<td>207</td>
<td>188</td>
</tr>
<tr>
<td>$Q_0$ at maximum field</td>
<td>$7.8 \times 10^9$</td>
<td>$4 \times 10^9$</td>
<td>$1.4 \times 10^{10}$</td>
</tr>
</tbody>
</table>

*1: KEK recipe consists of Centrifugal Barrel Polishing (CBP) of 135-235 µm, light Chemical Polishing (CP) of 1µm, baking at 750°C for 3 hours, Electro-Polishing (EP) of 80 µm, High-Pressure Rinse (HPR) with ultra-pure water, and low-temperature baking at 120°C for 48 hours.

*2: Buffered Chemical Polishing uses a mixture of HF, HNO₃ and H₃PO₄ at a volumetric ratio of 1:1:2, whereas CP uses the ratio of 1:1:1. BCP is slower than CP, but can reduce the temperature increase during the polishing.

### ACKNOWLEDGEMENTS

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Figure 3: $Q_0$ - $E_{acc}$ curves of the new LANL 805 MHz single-cell cavity #3, together with the dissipated cavity power lines and design gradients for SNS, European XFEL and ILC as references as well as the previous maximum $E_{acc}$ [7].

REFERENCES