Loaded Q Calculations for the ESS High Beta Linac

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Introduction

The purpose of this note is to set the loaded Q value for the 5 cell high beta cavities. The lattice data is from the OPTIMUS lattice released on 26-July-2013. The beam current assumed is 62.5 mA. This note uses the formulation described in the note "Loaded Q Calculations for the ESS Superconducting RF Linac", ESS Docs Document 295.[1]

Lattice Parameters

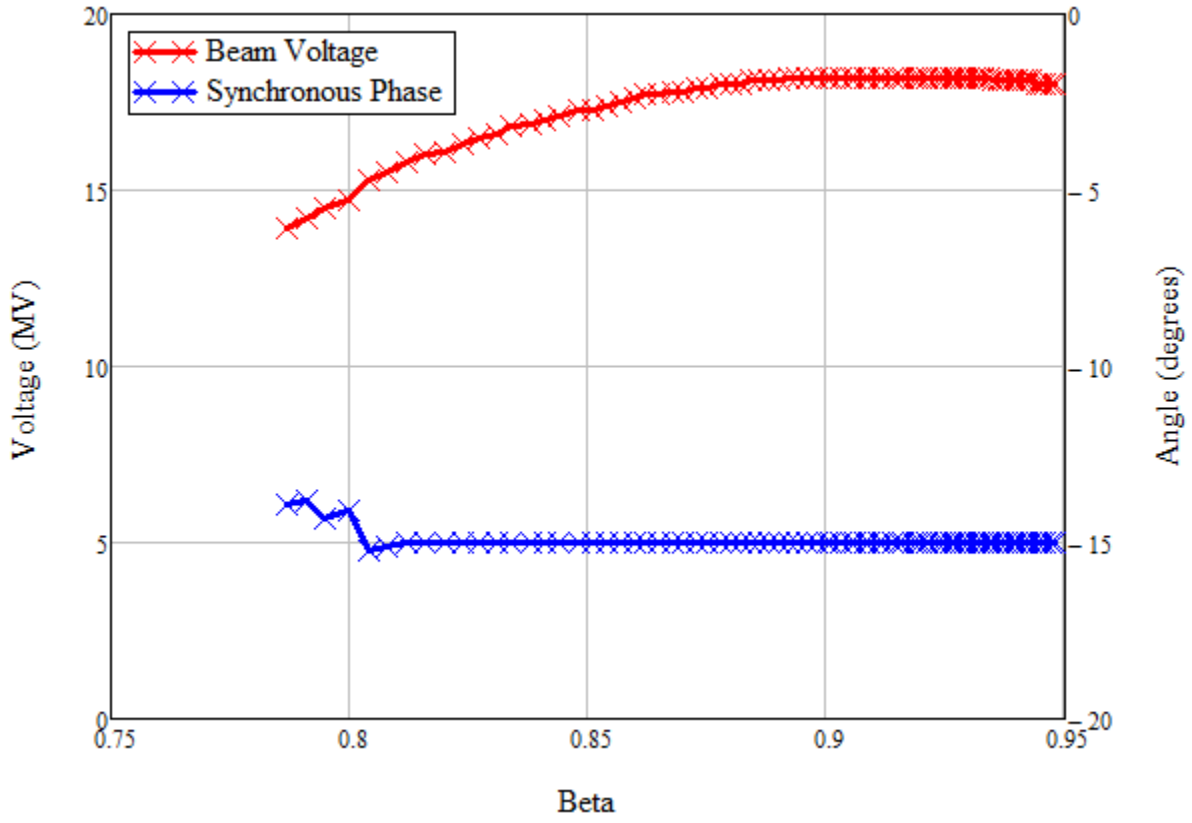

Figure 1. Beam Voltage and Synchronous Phase for the High Beta Section of the ESS OPTIMUS Lattice.

[1] "Loaded Q Calculations for the ESS Superconducting RF Linac", http://eval.esss.lu.se/cgi-bin/public/DocDB/ShowDocument?docid=295, Dave McGinnis

Field Map

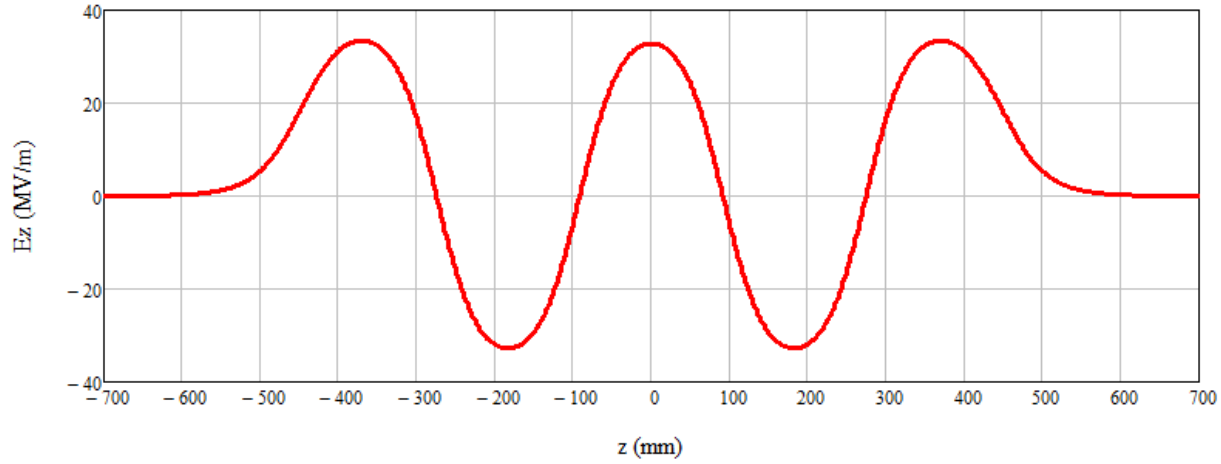

Figure 2. Five cell high beta field profile with β_g=0.86, a peak surface field of 40 MV/meter, and a stored energy of 128 J.

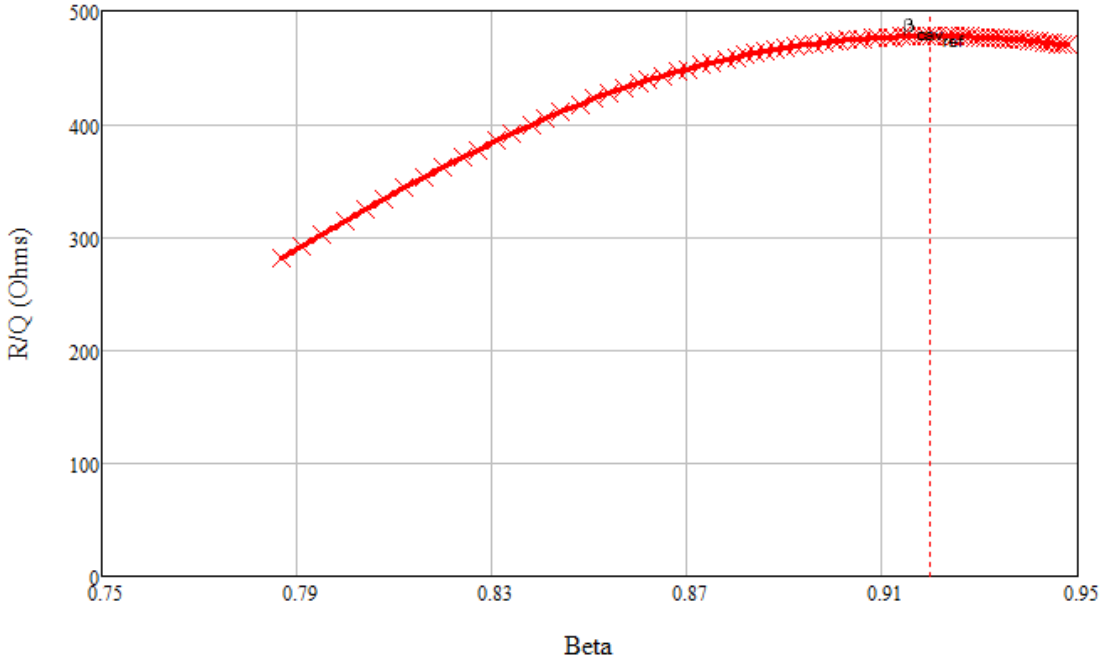

Figure 3. R/Q plot for the 5 cell High Beta Cavities. The maximum acceleration R/Q of 478 Ohms occurs at a β of 0.92 for cavity 53 (first cavity in the fourteenth cryomodule)

Optimum Loaded Q

For minimum reflected power of the entire high beta section, the Q_L was set by the operating point of the first cavity in the seventh cryomodule. At this operating point, β=0.87, the accelerating R/Q was 448 Ohms and the Q_L is 657×10^3. The forward and reflected power for this value of Q_L is shown in Figure 4.

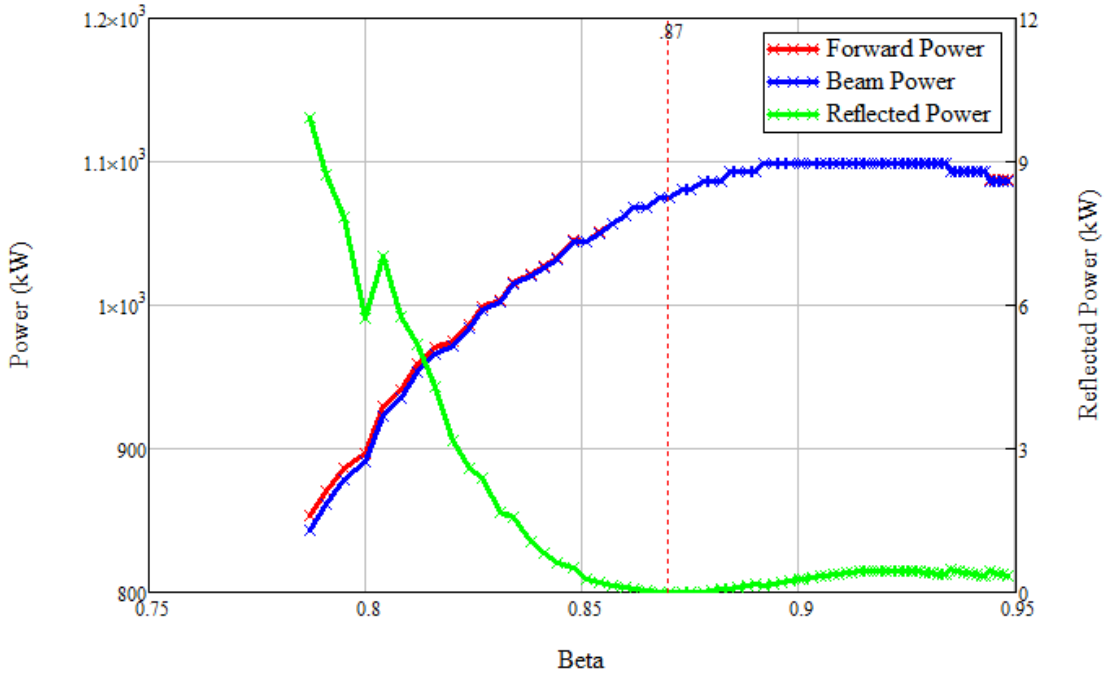

Figure 4. Forward and reflected power for the High Beta cavities with a Q_L of 657x10^3. The Q_L was chosen for the operating point of β=0.87 and a beam current of 62.5 mA.

Required Power as a function of Loaded Q

The optimum loaded Q value of 660,000 might require the coupler probe penetration to be deeper into the beam pipe aperture than is comfortable. In this section, the forward and reflected power as a function of loaded Q was examined and the results are shown in Figures 5-8. It was found at β=0.92, a Q_L of 760,000 requires 0.8% more power and Q_L of 860,000 requires 2.2% more power than the power required with Q_L of 660,000. Averaged over the entire high beta section, a Q_L of 660,000 reflects 1.1 kW, a Q_L of 760,000 reflects 6.8 kW and a Q_L of 860,000 reflects 20.5 kW.

Conclusions

The desired loaded Q for the 5 cell high beta cavities at 62.5 mA of beam current for the OPTIMUS lattice is 660,000. However, a loaded Q of 760,000 would require an insignificant amount of more forward power and the increased reflected power is well with the range of the klystron circulators.

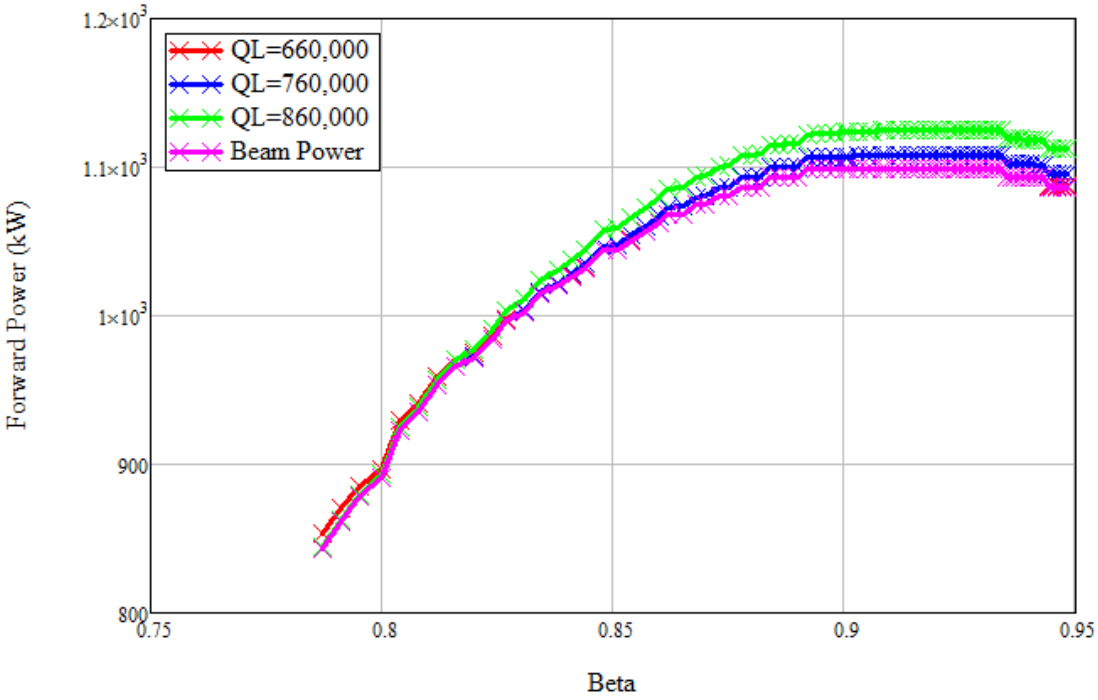

Figure 5. Required peak forward power as a function of loaded Q (Q_L).

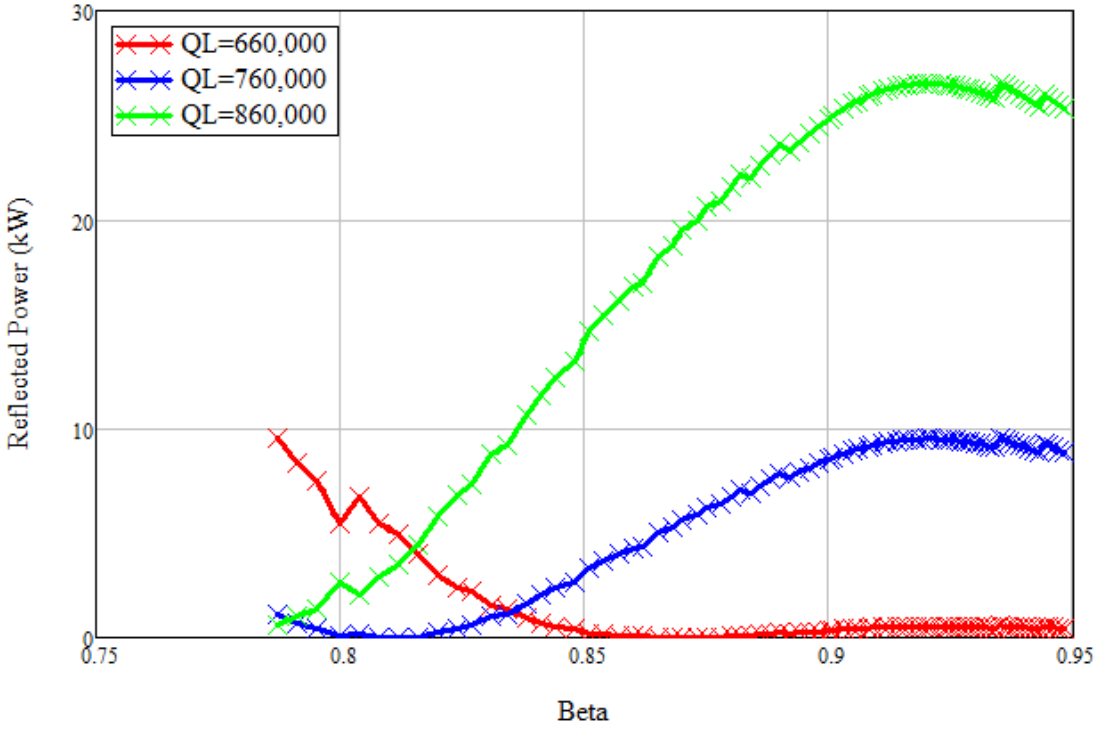

Figure 6. Reflected power as a function of loaded Q (Q_L).

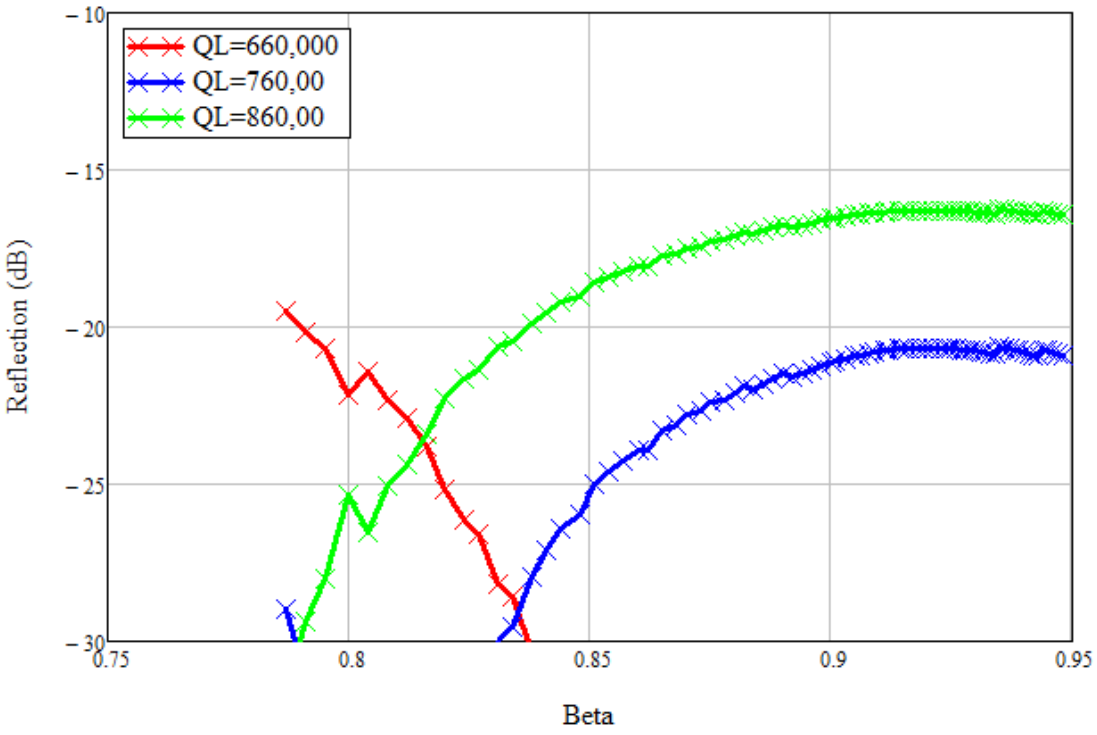

Figure 7. Reflection Coefficient as a function of loaded Q (Q_L).

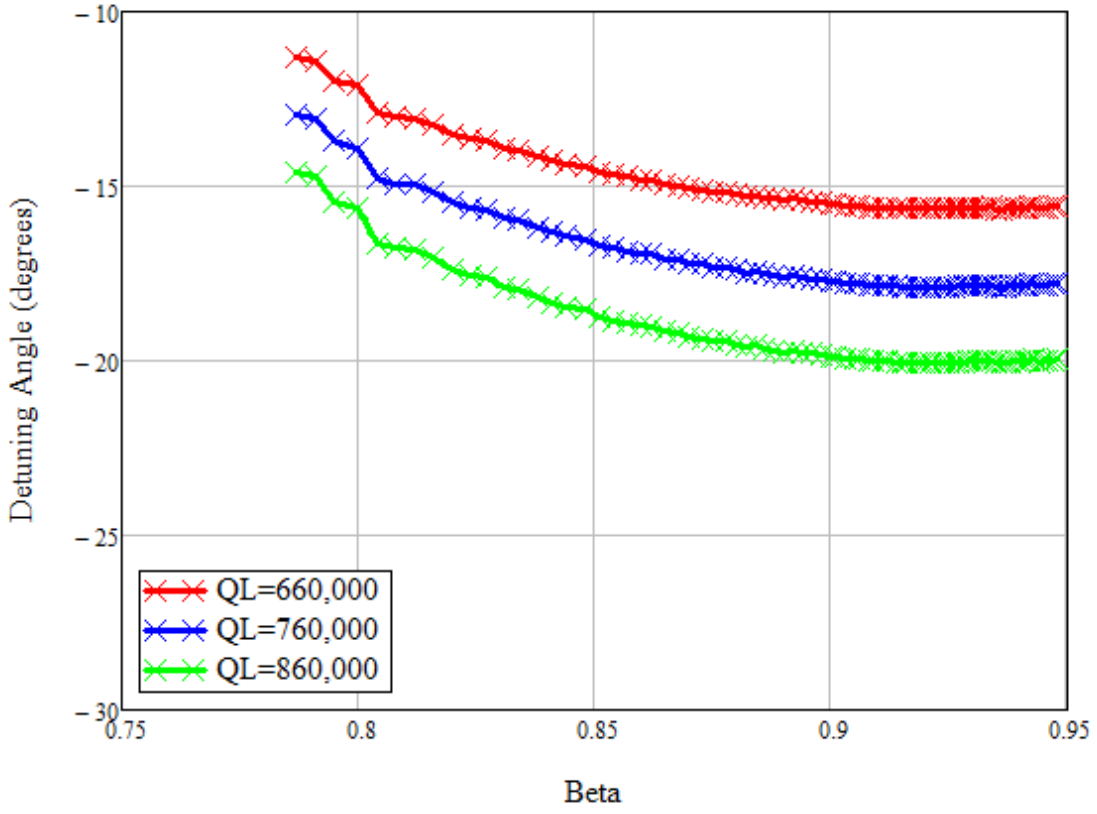

Figure 8. Required cavity detuning angle as a function of loaded Q (Q_L).