Loaded Q Calculations for the ESS Spoke Linac

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Introduction

The purpose of this note is to set the loaded Q value for the double spoke 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

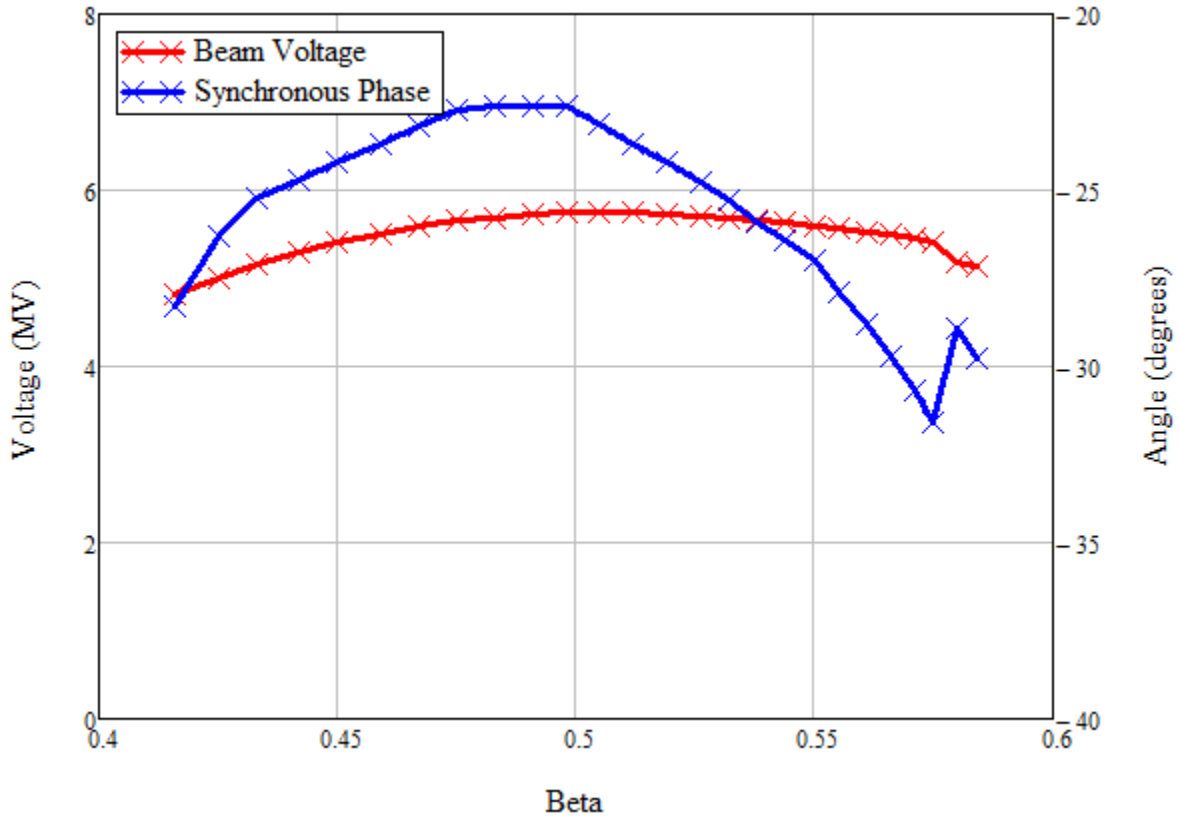

Figure 1. Beam Voltage and Synchronous Phase for the Spoke Section of the ESS OPTIMUS Lattice.

[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

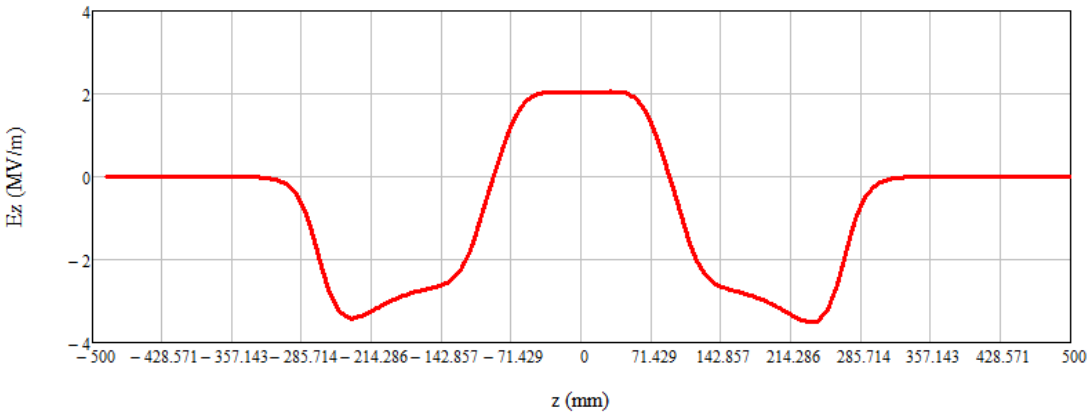

Figure 2. Spoke Field Profile for a stored energy of 1 J.

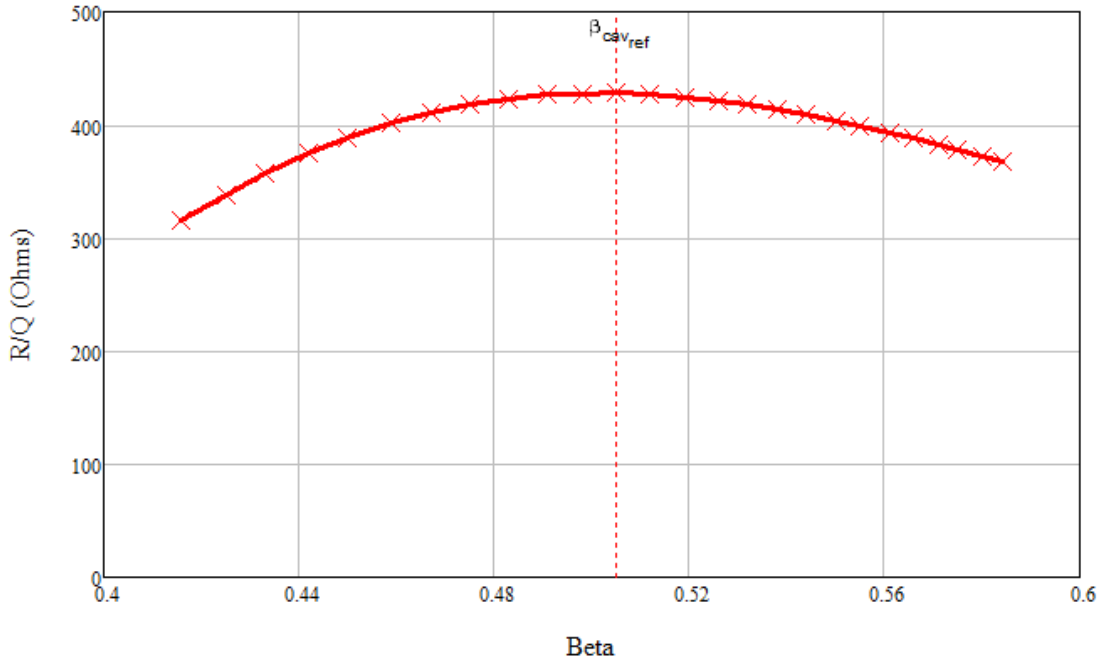

Figure 3. R/Q plot for the Spoke Cavities. The maximum acceleration R/Q of 428 Ohms occurs at a β of 0.505 for cavity 11(second cavity in the sixth cryomodule)

Optimum Loaded Q

For minimum reflected power of the entire medium beta section, the Q_L was set by the operating point of the second cavity in the fifth cryomodule. At this operating point, β=0.505, the accelerating R/Q was 428 Ohms and the Q_L is 233×10^3. The forward and reflected power for this value of Q_L is shown in Figure 4.

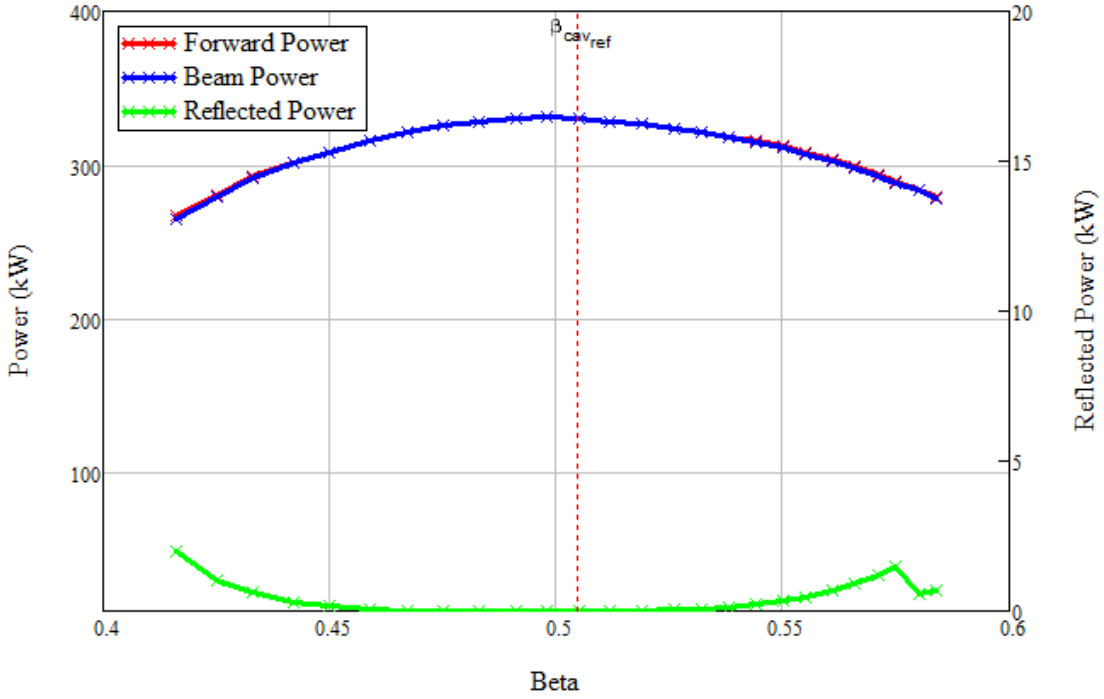

Figure 4. Forward and reflected power for the Spoke cavities with a Q_L of $233x10^3$. The Q_L was chosen for the operating point of β=0.505 and a beam current of 62.5 mA.

Required Power as a function of Loaded Q

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=0.505, a Q_L of 175,000 requires 1.8% more power and Q_L of 285,000 requires 0.9% more power than the power required with Q_L of 230,000. The average reflected power for a Q_L of 175,000 is 9.4 kW (peak), for a Q_L of 230,000 it is 0.56 kW, and for a Q_L of 280,000 it is 1.8 kW.

Conclusions

The desired loaded Q for the spoke cavities at 62.5 mA of beam current for the OPTIMUS lattice is 230,000. However, a loaded Q of 175,000 would require an insignificant amount of more forward power and the increased reflected power is well with the range of the circulators.

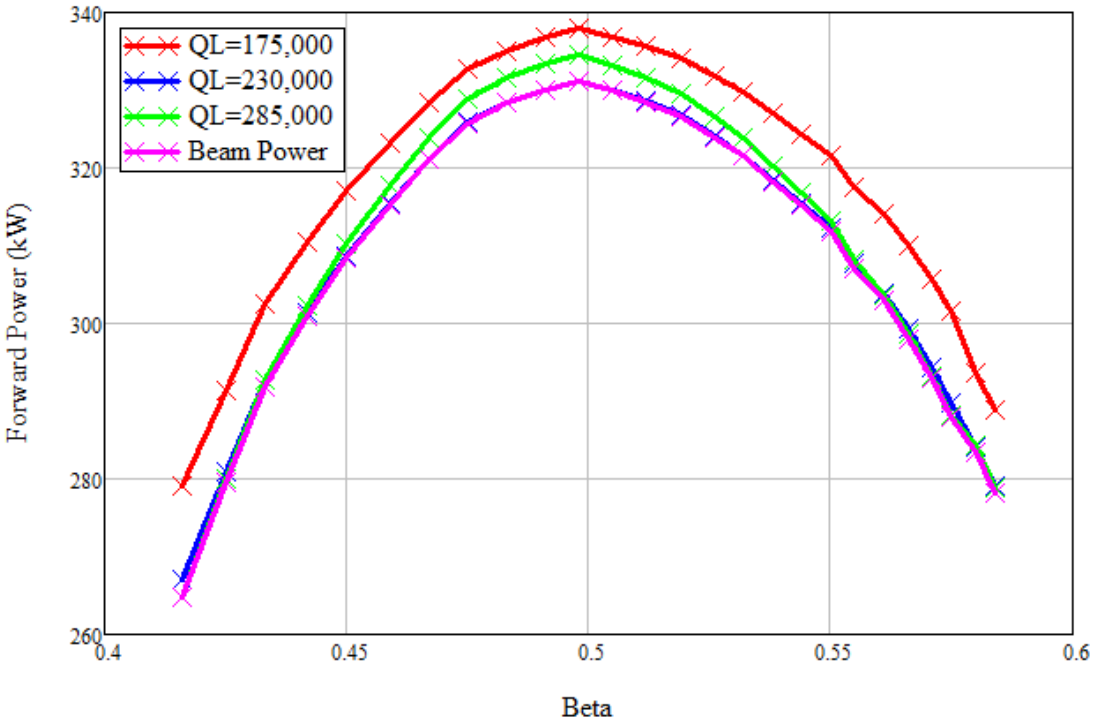

Figure 5. Required peak forward power as a function of loaded Q (Q_L). At β=0.505, a Q_L of 175,000 requires 2.0% more power and Q_L of 285,000 requires 0.9% more power than the power required with Q_L of 230,000.

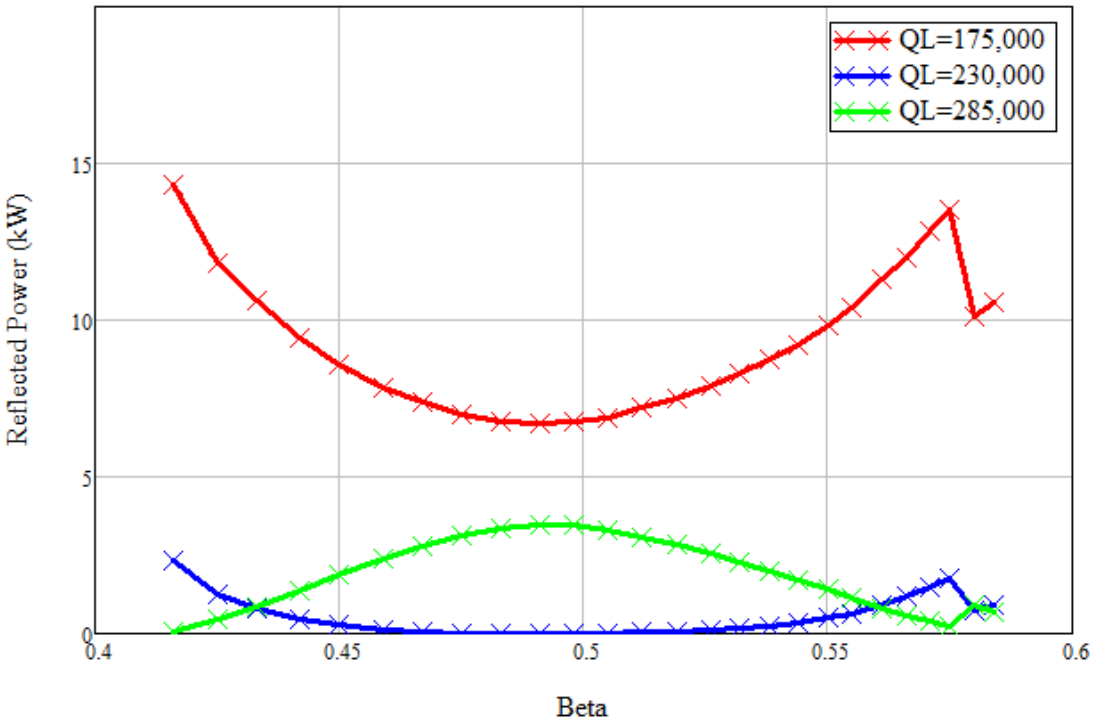

Figure 6. Reflected power as a function of loaded Q (Q_L).

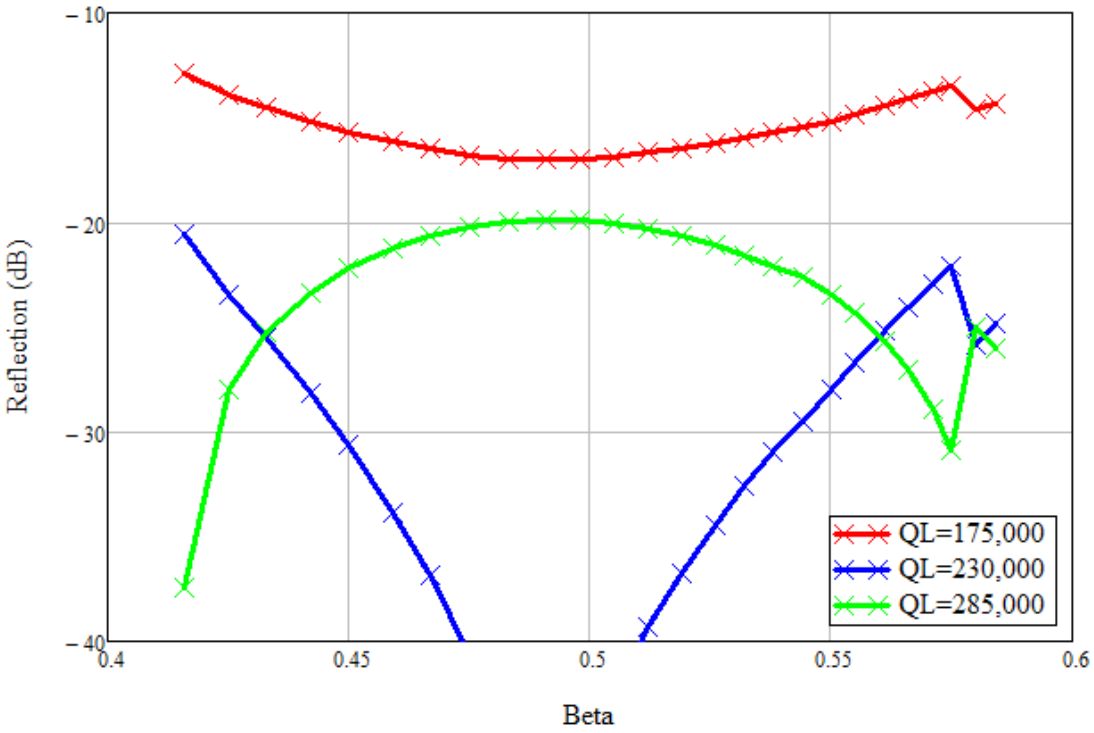

Figure 7. Reflection Coefficient as a function of loaded Q (Q_L).

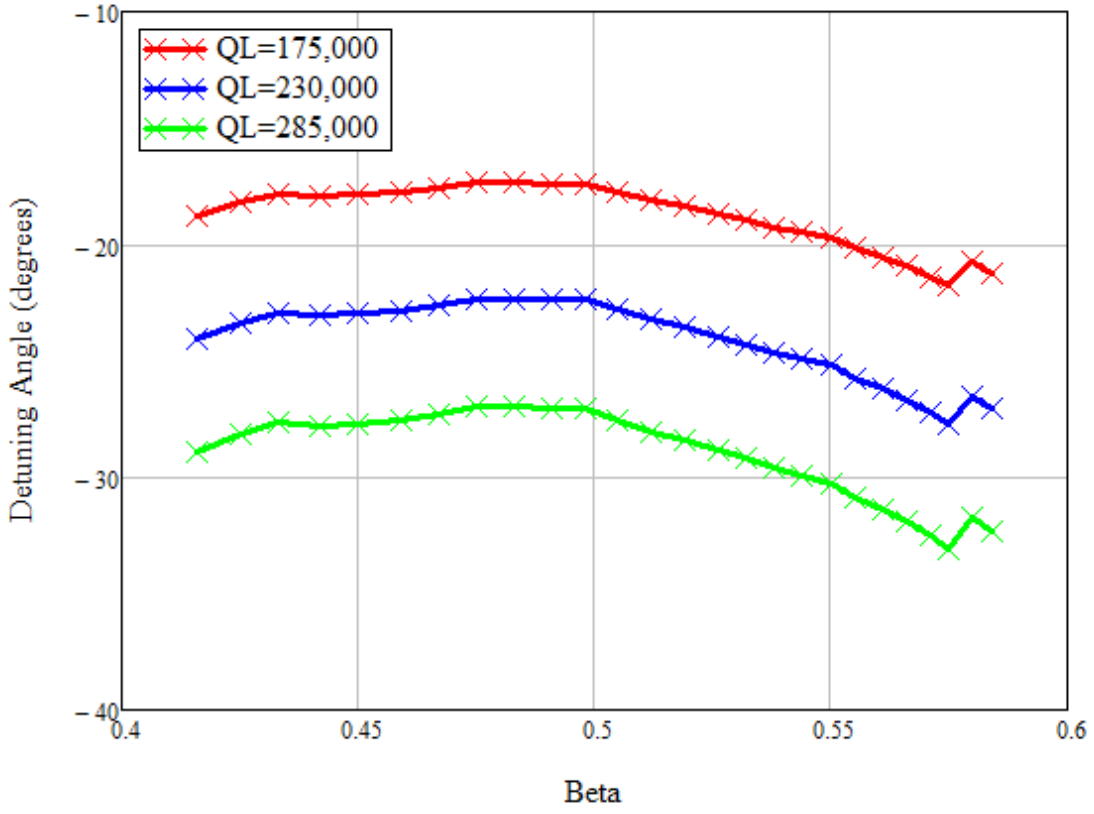

Figure 8. Required cavity detuning angle as a function of loaded Q (Q_L).