CEBAF power limits

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29 March 2022

History

- 1986: 4 GeV CEBAF specification 200*5 μA, 1 mA through cavities
- 1998: Preliminary 12 GeV specification assumed original 1 MW Environmental Assessment beam power limit would remain
- 2001: 100 MeV cryomodule with 13 kW klystrons assumed
- 2005: Cavity cell shape defined assuming 460 μA with 13 kW klystrons aka 5*86 (A+C) +6*5(D) with factor of two safety margin for dipole beam breakup (BBU) instability. TN-05-009
- 2007: Environmental Assessment allowed 1 MW each to Halls A and C. 12 GeV Project retained the original 1 MW beam power limit.
- 2017: C75 cavity specification retained 460 μA assumption. TN-17-055

Design choices from current limit

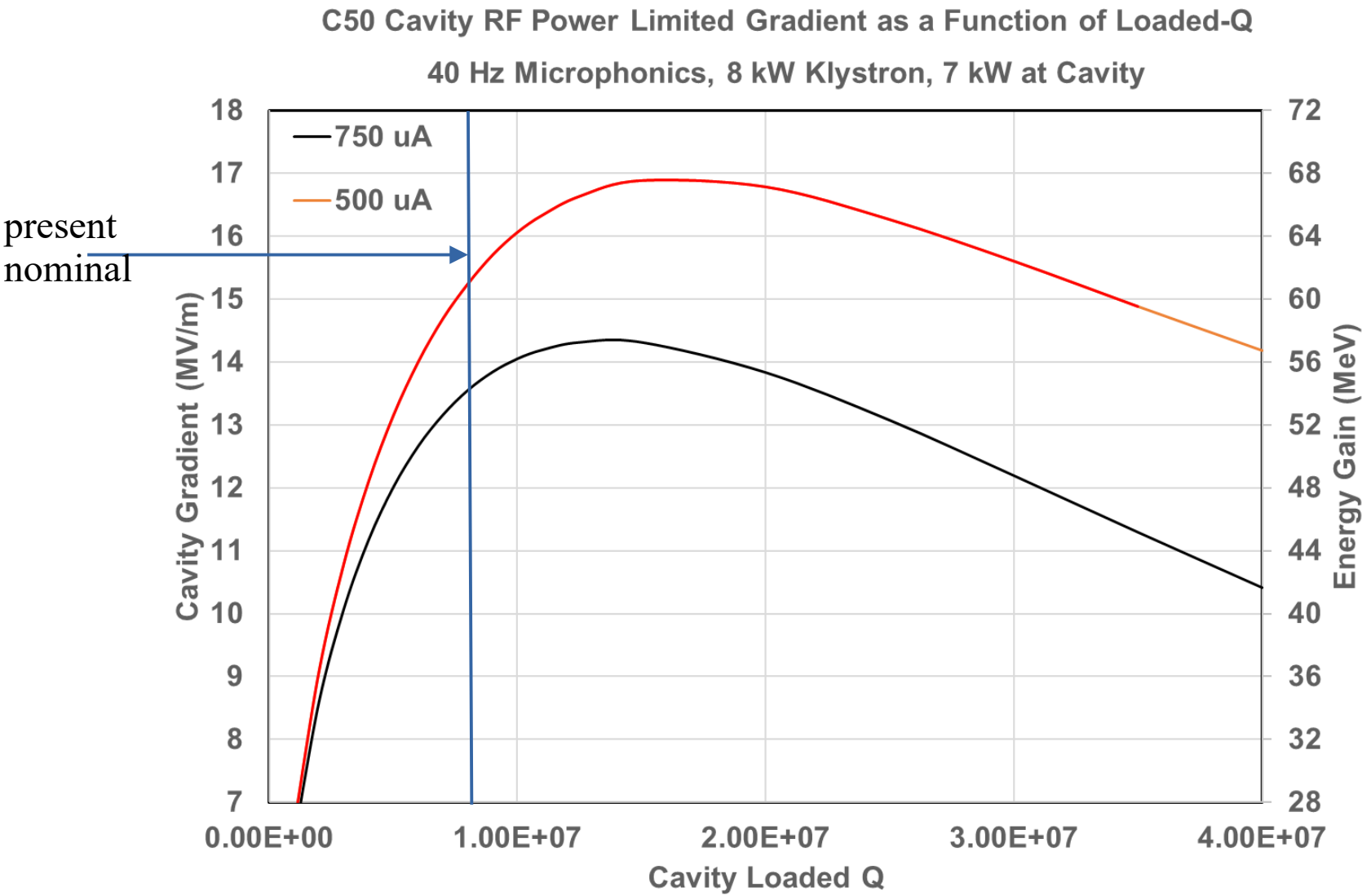
- Simplifying, required $P = V^2/R+I^2*R+noise$
- If one designs for high V at fixed klystron power via high input R, allowed I is lower.
- If one assumes lower current then less BBU damping is needed so choice for higher order mode couplers very different for C100s than for original CEBAF. Measurements suggest lowest C100 BBU threshold ~900 μA, just below design intent.

Another Constraint

Beam dumps have to be cooled. Halls A and C beam dumps are rated at 1 MW each but the intermediate heat exchanger (IHX) which interfaces between their radioactive LCW systems and the cooling towers is rated at 1.1 MW. JLab Facilities group has been asked to begin planning for an upgrade to 2 MW, funding permitting. Two years required after funding.

Safety Documentation

- Safety Configuration Management Board met 31 January. Four DOE personnel attended as guests.
- JLab ESH is arranging for tests of groundwater tritiation and flow rate through site per DOE request.
- The IHX system can tolerate a short (~30 minute) test of the RF/SRF system up to 1.5 MW; site office approval needed.
- It should be possible to temporarily adjust the PSS/MPS hardware/firmware to allow the test.



Courtesy of
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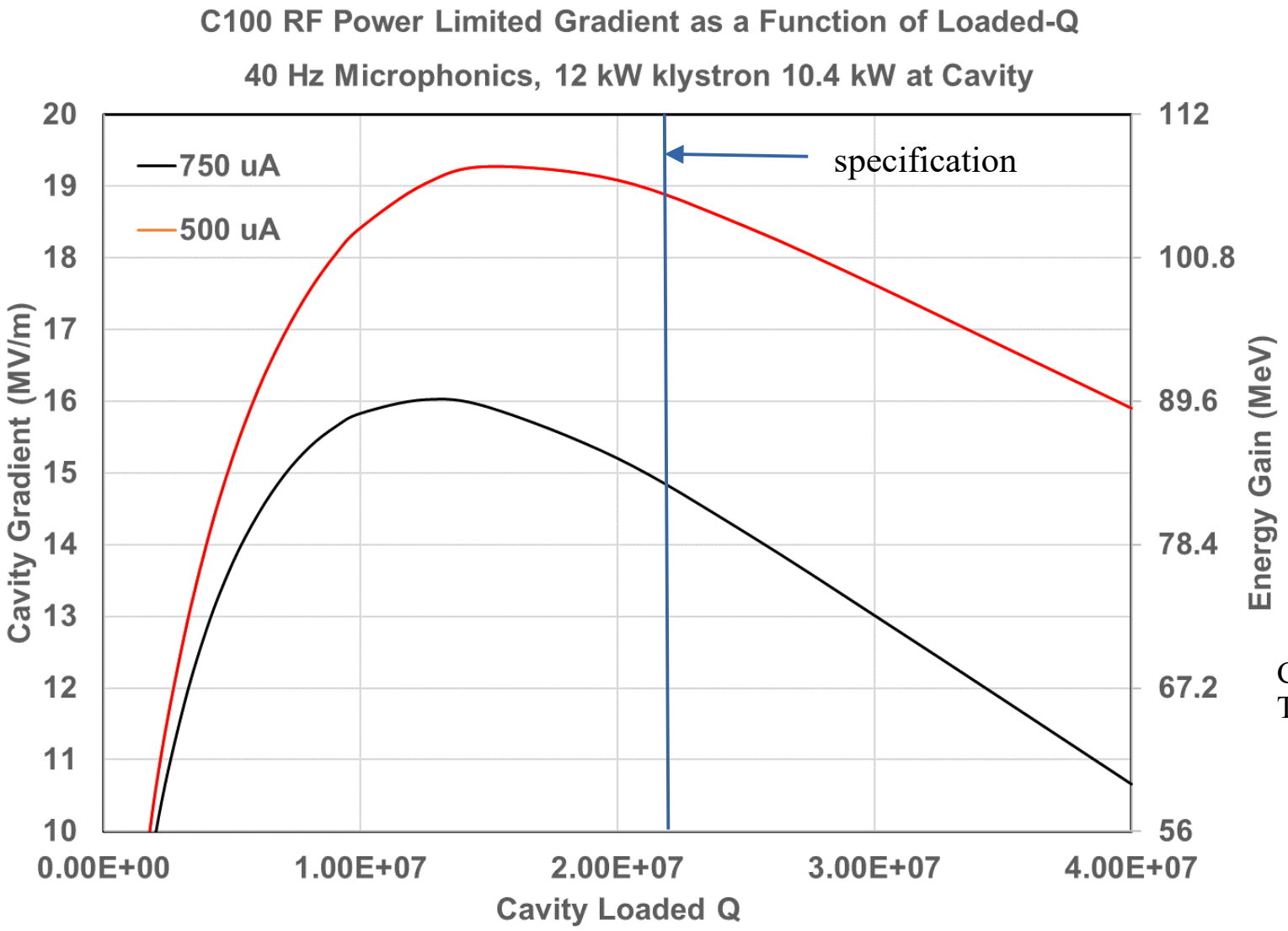

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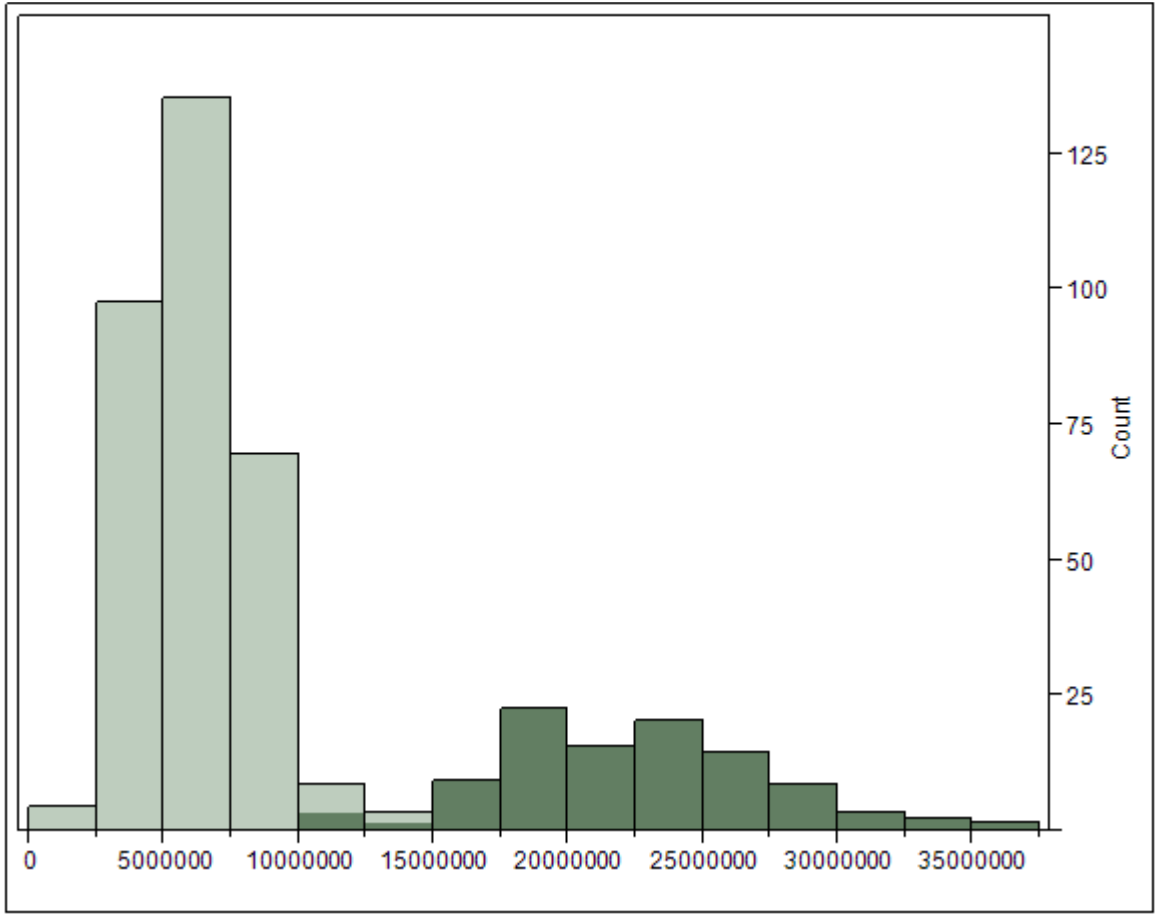
Altering the RF/SRF current-voltage balance

- MIT Rad Lab Series (1947-1948+) discusses methods for altering impedance of waveguide and cavity systems. Volume 9 has a long section on stub tuners.
- There are three-stub tuners installed on all C100 cavities. Smith chart analysis suggests these may not suffice to sufficiently lower input Q so eight five-stub tuners have been ordered and will be installed during the present maintenance down. These should allow factor of two Q reduction. Both types will be tested this year for efficacy.
- SRF experts have concerns about C100 window heating because it was observed that a ceramic RF window cracked at 200 C in a test fixture. Machine limit to be set at 150 C. (Stub tuners will change node locations in system so window heating will change from that in present setup.)

Conclusion

- Documentation and the machine protection system limits derived from it should no longer be an issue within two years.
- Facilities is planning heat removal upgrade from 1.1 MW when funding permits.
- Tests will be performed by end of 2022 to determine the limits of the RF/SRF systems and how they may be mitigated. If the stub tuners work, they will be installed on all input-Q limited cavities as funding permits.
- It is my hope that it will be possible to deliver 70 μA each to Halls A and C at 11 GeV before 2026 in parallel with 25 kW to B and 60 kW to D, 1625 kW total.

Qexternal (R) distribution in CEBAF now



C100s, C75s are dark