Commissioning and First Results from the Fermilab Cryomodule Test Stand

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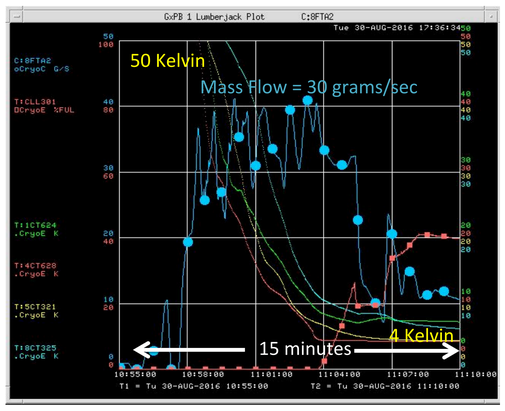
Abstract

A new test stand dedicated to Superconducting Radiofrequency (SRF) cryomodule testing, CMTS1, has been commissioned and is now in operation at Fermilab. The first device to be cooled down and powered in this facility is the prototype 1.3 GHz cryomodule assembled at Fermilab for LCLS-II. We describe the demonstrated capabilities of CMTS1, report on steps taken during commissioning, provide an overview of first test results, and survey future plans.

pCM installed and ready for first powered testing

Cooldown

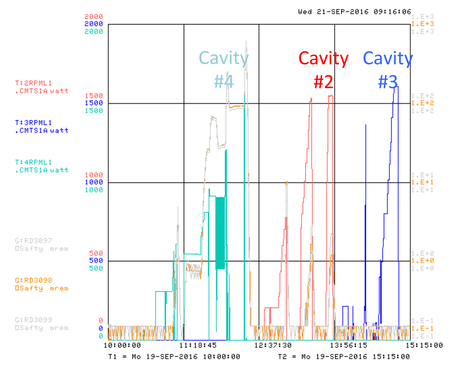
Cooldown from room temperature to 50 Kelvin was achieved over two days in a controlled fashion. 'Fast' cooldown to 4 Kelvin followed almost immediately thereafter and was accomplished in ~15 minutes with helium mass flow of 30 grams/sec.



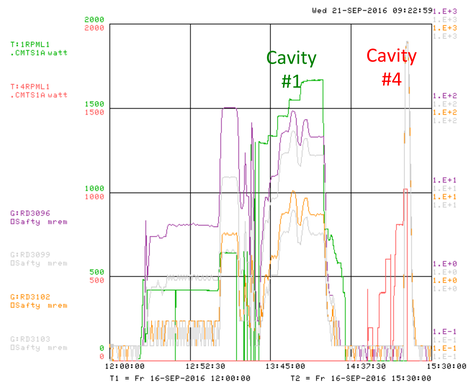
Temperature (K) and mass flow (g/s) during 'Fast' cooldown

First pCM Cold Results

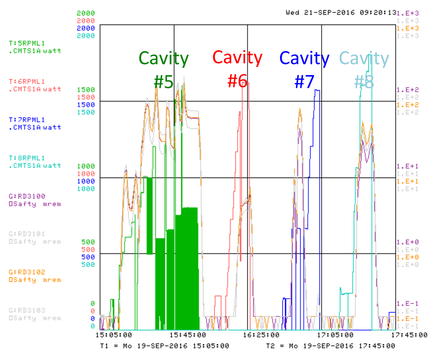
All cavities are cold and have been energized to a power equivalent to **16 MV/m** (administrative limit). All but #4 have operated at this gradient in continuous wave. #4, #5 exhibit field emission. Other cavities show little, if any, FE or it processed away. All cavities were operated on resonance at 1.3 GHz with LLRF 'frequency locked'.



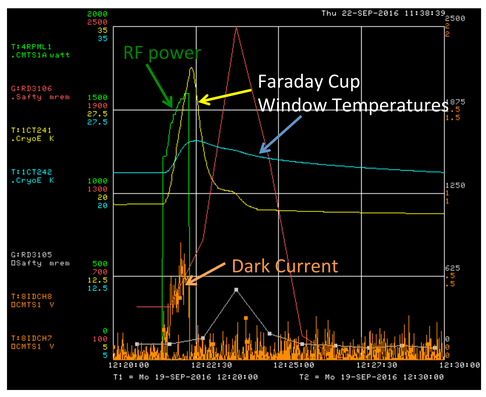
Cavities 2, 3, 4 (reprise): Power and Field Emission



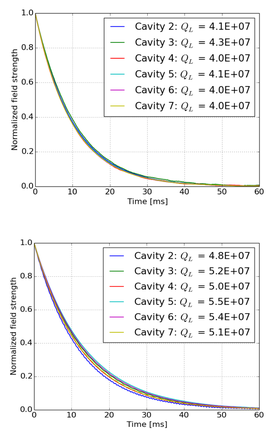
Cavities 1, 4: Power and Field Emission



Cavities 5, 6, 7, 8: Power and Field Emission



Indications of dark current, ~50 nA, produced during Cavity #4 operation at 1600 Watts with low duty factor. Scale is 100 nA/Volt. Temperature sensors on a vacuum window through which dark current passes show a sympathetic response.



Q_{ext} as measured by the LLRF system. Left graph is 'as found' after cooldown and right is after adjusting coupler antenna. Nominal value is $4.1X10^7$.

Summary

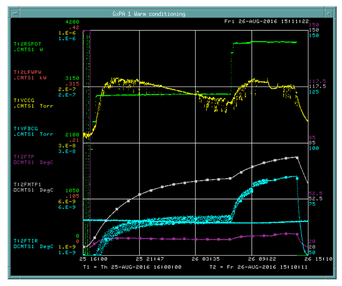
CMTS1, Fermilab's newest cryomodule testing facility, has become operational and is now ready to support testing of CM's for LCLS-II. The prototype CM is installed, cold, and the first stages of powered cold testing are in progress. An aggressive LCLS-II CM testing program, 28 days testing cycle per CM, is anticipated.

Introduction

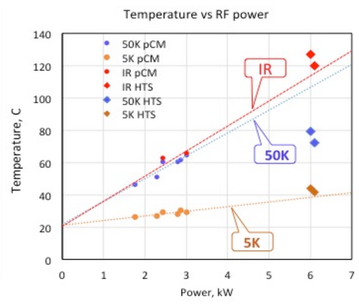
LCLS-II is a next generation hard x-ray light source based on a superconducting RF electron linac operating in continuous wave regime. As one of the partner labs Fermilab is responsible for the design of the 1.3 GHz Cryomodules (CM's) as well as assembly and testing for seventeen of the necessary thirty-five CM's. Additionally Fermilab is designing and will assemble and cold test two 8-cavity 3.9 GHz (third harmonic) cryomodules.

Off Resonance (warm) Conditioning

No multipactoring or breakdown were observed during warm conditioning. Cavity vacuum was insensitive to the power level. The common warm coupler vacuum reached a maximum $3.X10^{-7}$ Torr and gradually improved during processing. Conditioning was done at a peak power of 4 kW.



Cavity #2 during warm conditioning



Comparison of Coupler Temperatures during Coupler Conditioning

Acknowledgements

Assembly, commissioning, and now operation of CMTS1 reflects the dedication of a large cadre of talented people both at Fermilab and the institutions it has collaborated with over the years so as to build up its SRF infrastructure. The authors acknowledge the designers and builders of the cryomodules for which this test facility has been built, and especially the LCLS-II pCM at Fermilab.

Almost everyone involved in bringing CMTS1 to its current state is indebted to Helen Edwards and we honor her memory. Without her vision, technical acumen, and coaching, SRF technology would not be in the mature state found today at Fermilab .

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