Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)

SRF 2015 WHISTLER

CORNELL MULTI–CELL T MAPPING AND CONCLUSIONS

TUPB081

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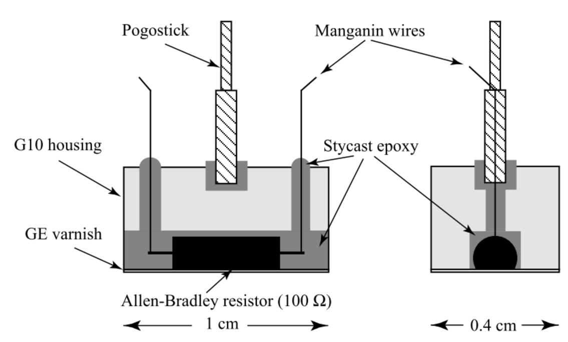
Introduction

Multi-cell temperature mapping (T-map) system for 1.3GHz SRF Nb cavities has been developed at Cornell. T-map system consists of nearly two thousand thermometers array positioned precisely on an exterior cavity wall and is capable of detecting small increases in temperature. It has achieved a 1mK resolution of niobium surface temperature rinsing in superfluid liquid helium. We have upgraded the system to be capable of monitoring the temperature profiles of quench spot on cavity. The recent results , especially quench localizations, of T-map during cavity tests and details are presented on poster.

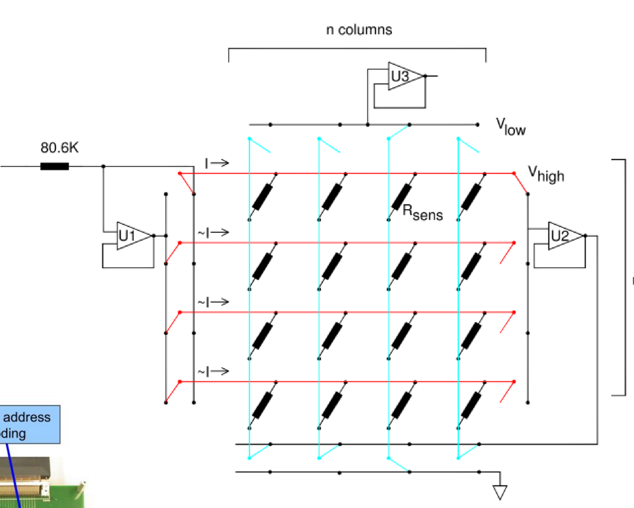
Cornell's multi-cell T-map system

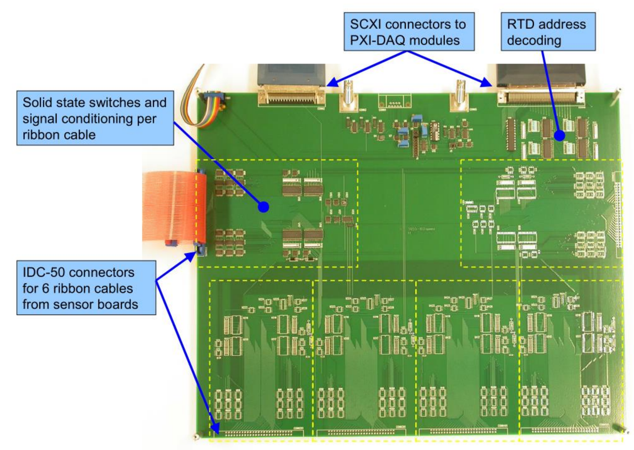
- The sensors are a 100Ω carbon Allen-Bradley resistor (5% 1/8 W). The resistivity increases from the 100Ω r. temp. value to about 10kΩ at 2K. Current source provides about 4uA through the nominal 10KΩ sensor at 2K, "typical" signal across a sensor is approximately 40mV.
- T-map covers 7-cells in total (two sets of 3cell boards + one sets of 1cell boards). The quantity of thermometers for the whole system is 1848 (24 boards * 11 sensors * 7cell).
- A new multiplexing scheme is applied on our multi-cell T-map scan to reduce the number of wires. Each of an array of m×n resistive thermal sensors has one lead attached to a "column" wire, and one lead attached to a "row" wire. In the case of our implementation, there are 24 columns and 11 rows in each array, and our measurement system can process the results from up to 6 such arrays simultaneously. This multiplexing system allow to reduce the number of the wire from approximately four thousands to three hundreds.

Thermometer schematic



A new multiplexing scheme



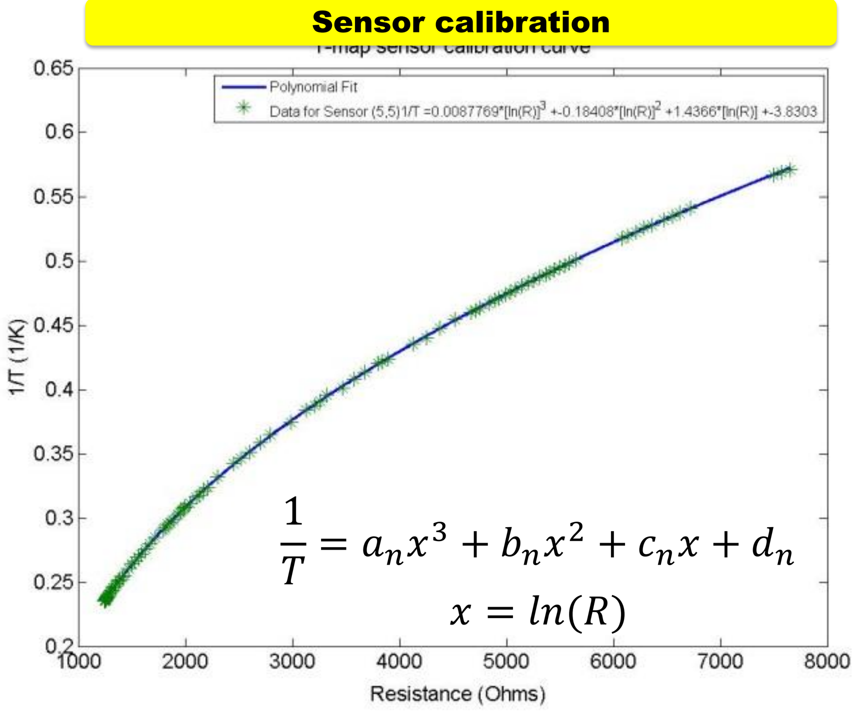


signal processing board

Sensor sensitivity and resolution

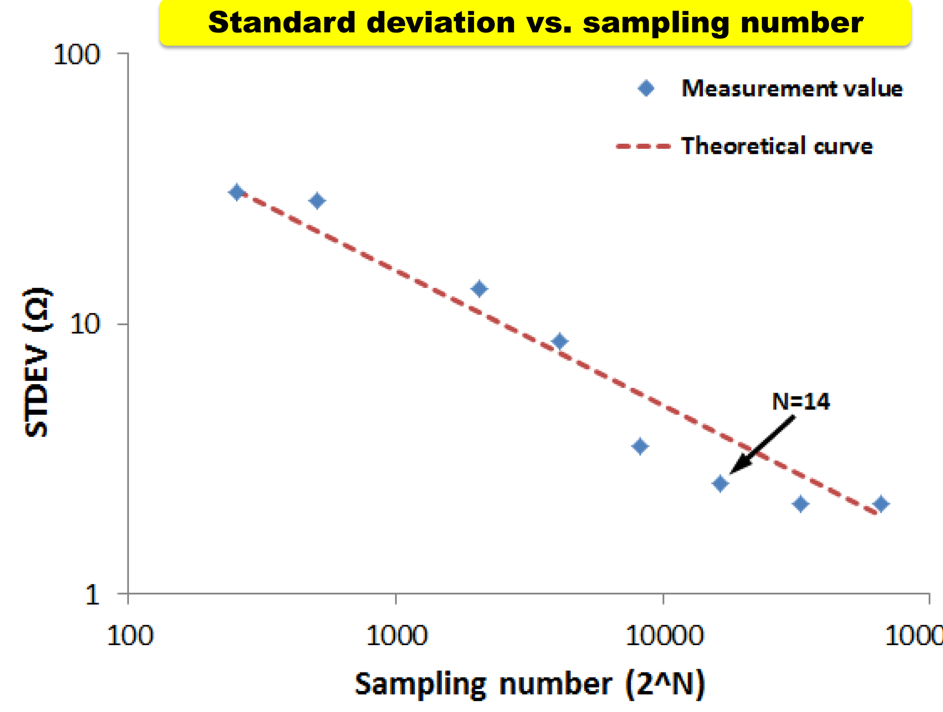
- The temperature rise of ~20mK on the exterior wall is estimated against a 1.3GHz SRF cavity with Qo of 2.0e10 at 16MV/m in 2.0K helium bath. The sensor is able to detect the temperature rise of the cavity wall with 25% efficiency . Thus the resolution of this T-map is required to be approximately 1mK.
- A well-calibrated Lakeshore Cernox thermometer is utilized as a temperature reference for the helium bath during cooling down from 4.2K to 1.6K.
- To avoid measurement error caused by bath temperature variation, the data-scan program measures bath temperature right after each T-mapping sensor measurement. Therefore each Allen-Bradley resistor has an individual calibration curve and fitting parameters.
- Fitting curves give dR/dT which represents the sensitivity of each sensor. dR/dT is approximately 30Ω/mK at 1.6K and 10Ω/mK at 2K .
- Increasing measurement sampling number (2^N) is an effective way to reduce noise from the electronic system. The standard deviation is reduced to about 2Ω, when N is set to 14, corresponding to a sampling number of about 16000. The noise from the electronic system is about 200μK in 2K helium bath; and 67μK in 1.6K helium. The total scan time is about 100s and the total noise of the T-map system is about 1mK. Multi-cell T-map has achieved the initial target resolution.

Sensor calibration



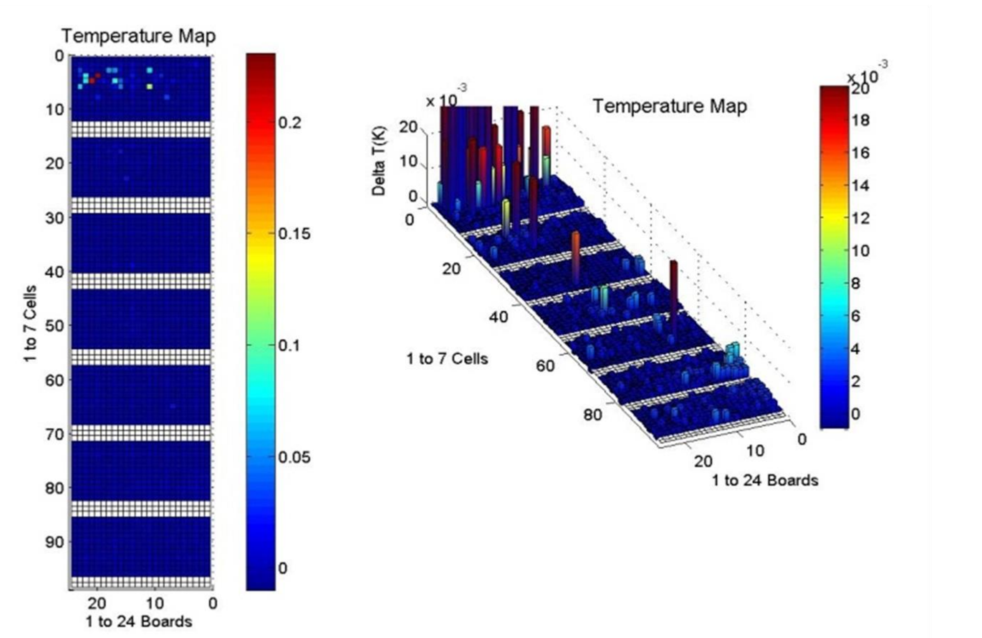
$$\frac{1}{T} = a_n x^3 + b_n x^2 + c_n x + d_n$$
$$x = \ln(R)$$

Standard deviation vs. sampling number

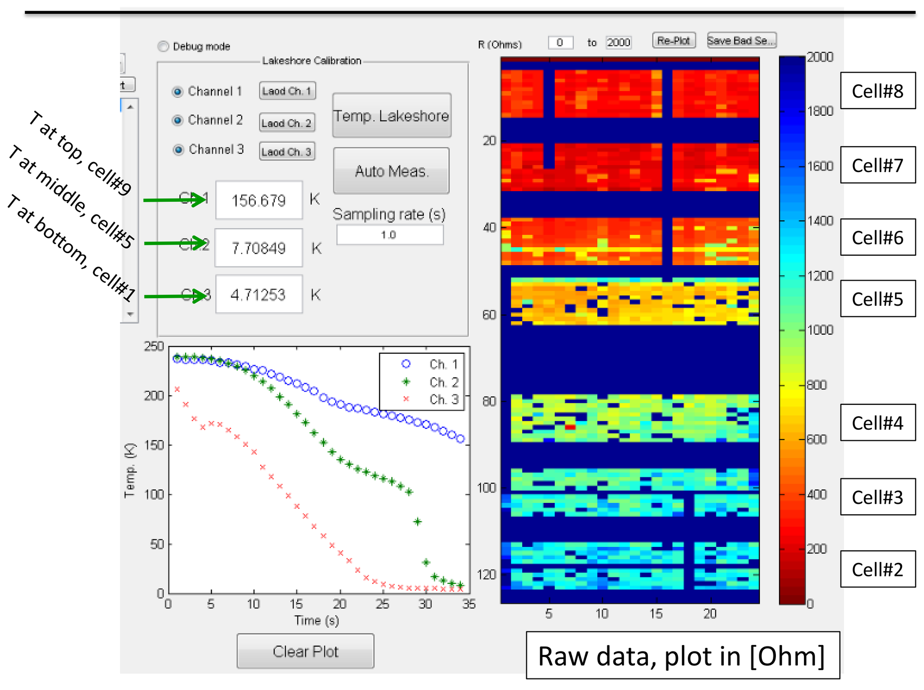


T-map results during Cryogenic test

HOT spot detection by T-map, A9

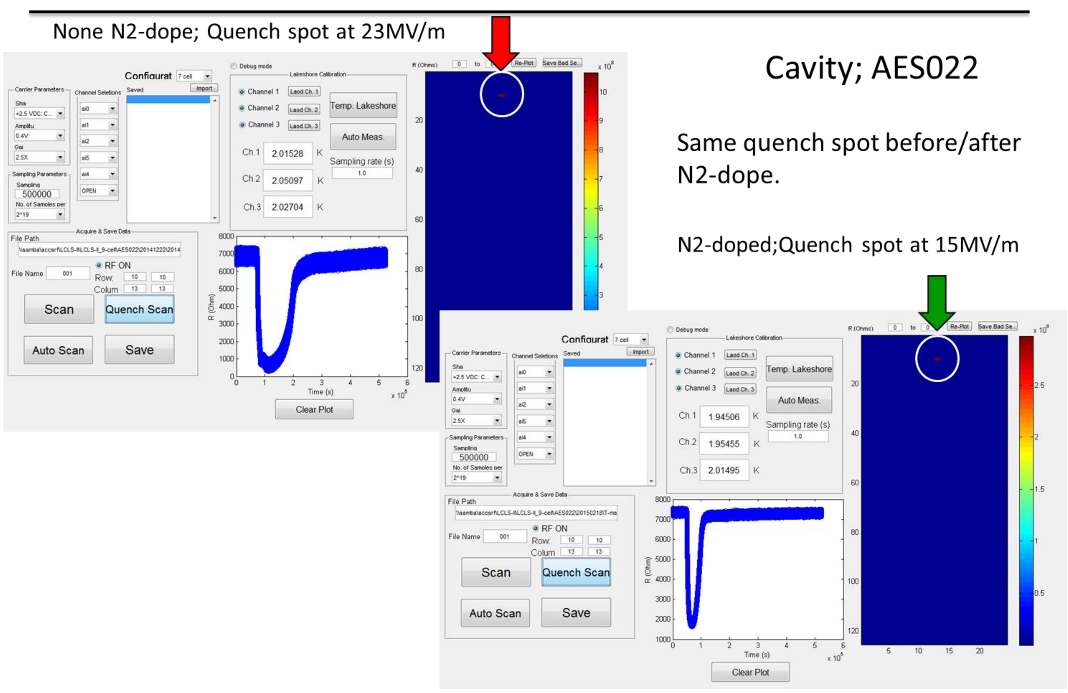


T-map meas. during fast cool



Raw data, plot in [Ohm]

Quench localization by T-map, AES022



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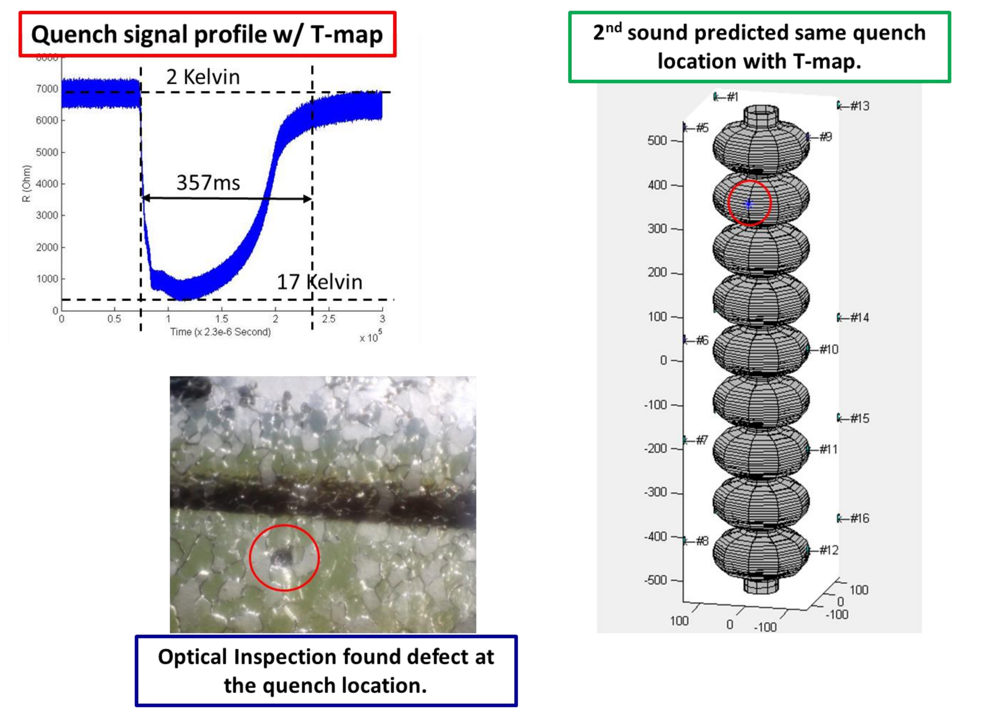
Quench localization by T-map, AES022



Optical Inspection found defect at the quench location.

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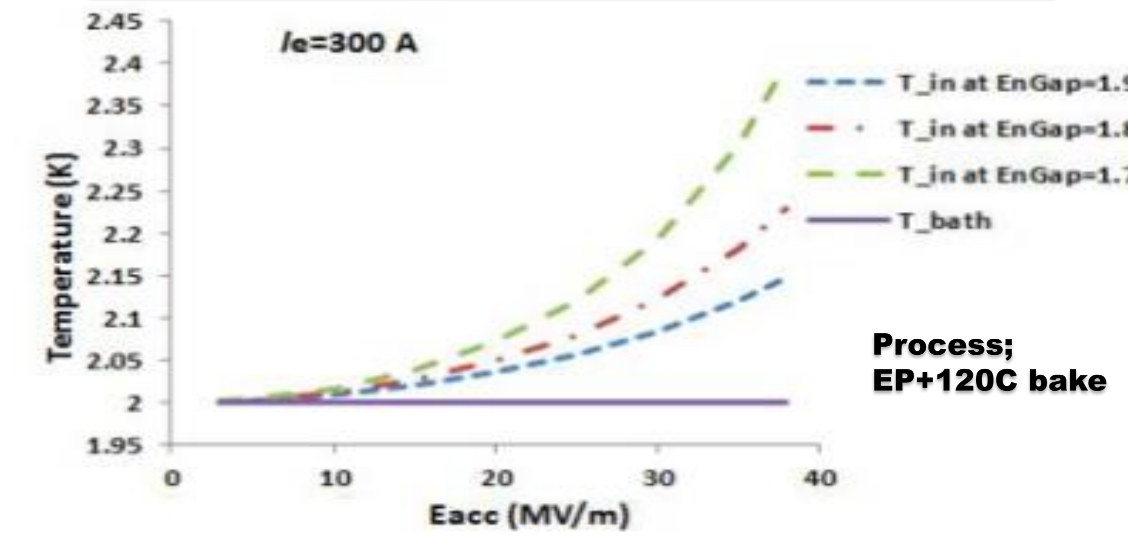
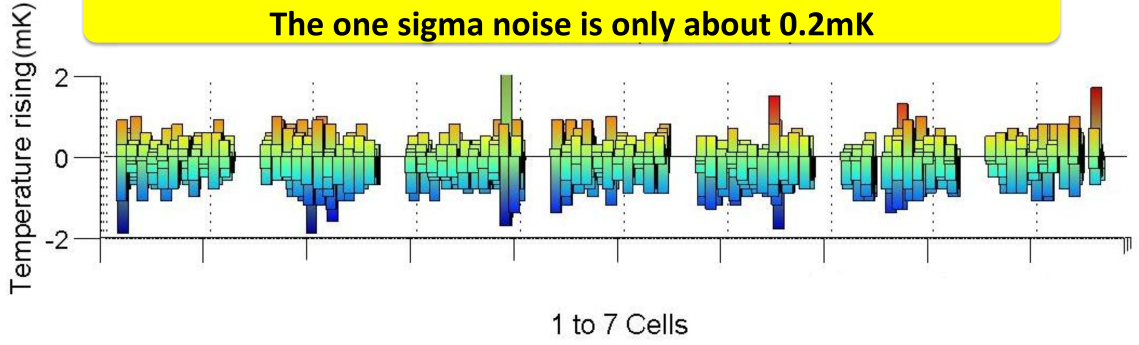
Simulation results on temperature rinsing vs. gradient



3-sigma noise level of T-map system.
The one sigma noise is only about 0.2mK



Conclusions

- Cornell multi-cell T-map system has been developed and successfully installed on multi-cell cavities and tested in 2K helium bath.
- The system had achieved 1mK resolution in 2K helium bath.
- Multi-cell T-map system becomes more functional by upgrading the control programs. The system is capable of not only detecting hot spot, but also monitoring cooling front during the fast cool, detecting quench signal with time profiles.
- The combination of T-map, OST, and optical inspection is very strong tool to investigate cavity quench phenomena. Further R&Ds with these tools are expected to bring more understandings of Nb SRF cavities
- More effort on converting T-map data into Qo-map of Nb cavity surface is ongoing.

CLASSE facilities are operated by the Cornell Laboratory for Elementary Particle Physics (LEPP) and the Cornell High Energy Synchrotron Source (CHESS) with major support from the National Science Foundation.