Summary of temperature mapping developments

G. Ciovati, M. Champion

AES Cavity Meeting, JLab, August 28th 2007

Outline

- Existing capabilities
  - Cornell 1-cell system, 1.5 GHz
  - DESY 1- and 9-cell system, 1.3 GHz
  - KEK 1-cell systems, 0.5 GHz
  - Saclay 1-cell system, 1.3 GHz
  - JLab 1-cell system, 1.5 GHz
- Development projects
  - FNAL 1- and 9-cell system, 1.3 GHz
  - LANL 9-cell system, 1.3 GHz
  - JLab, 2-cell system, 1.3 GHz

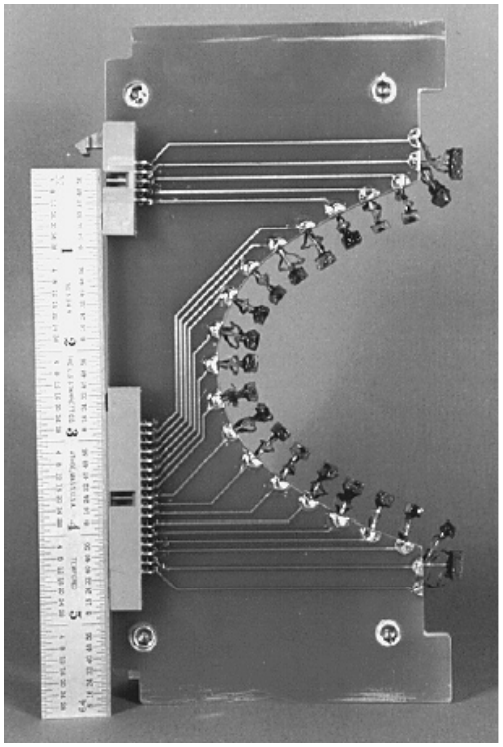
Rotating vs. fixed systems

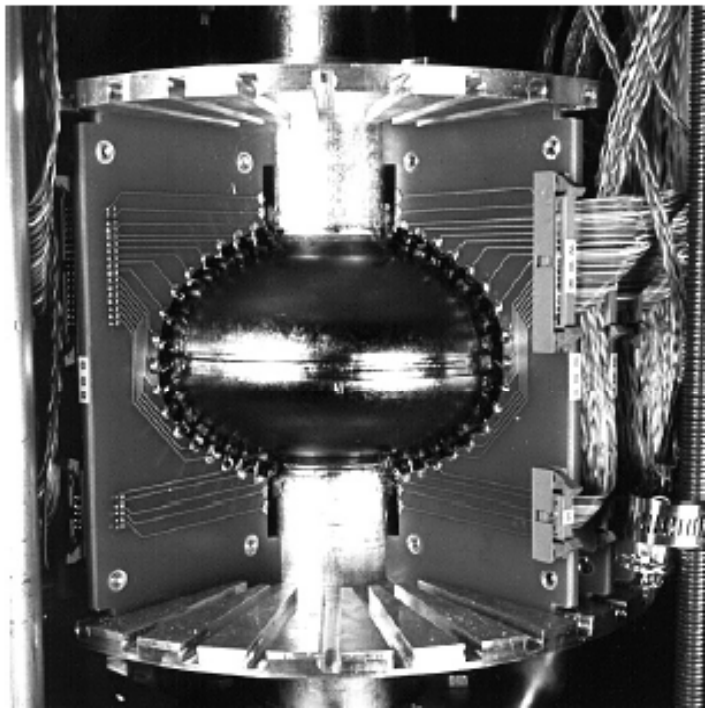
- Rotating T-map systems compared to fixed ones have:
  -  Reduced number of thermometers and cavity preparation time
  -  Longer data acquisition time
  -  Ability to detect only “stable” losses
  -  Reduced sensitivity in superfluid He

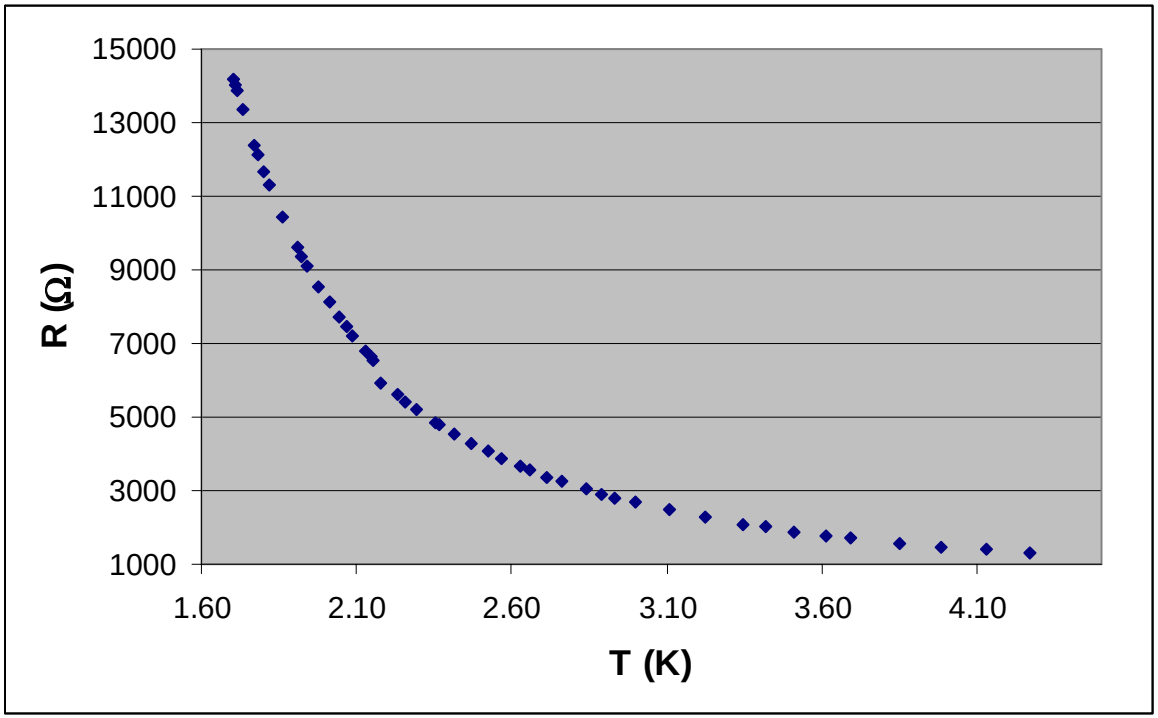
Existing capabilities

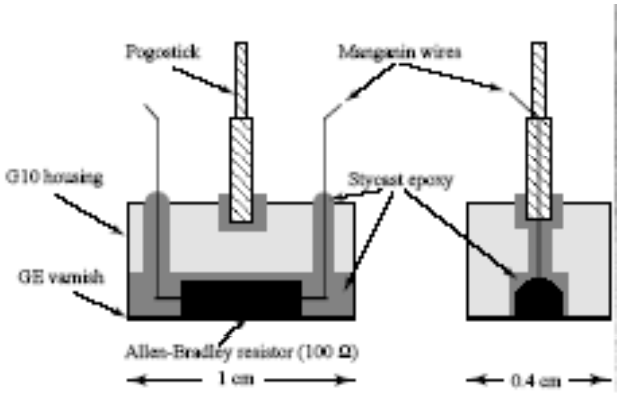
Cornell 1-cell 1.5 GHz

- 768 Allen-Bradley 100 Ω (1/8W) resistors, distributed in 36 boards, 10° spaced.





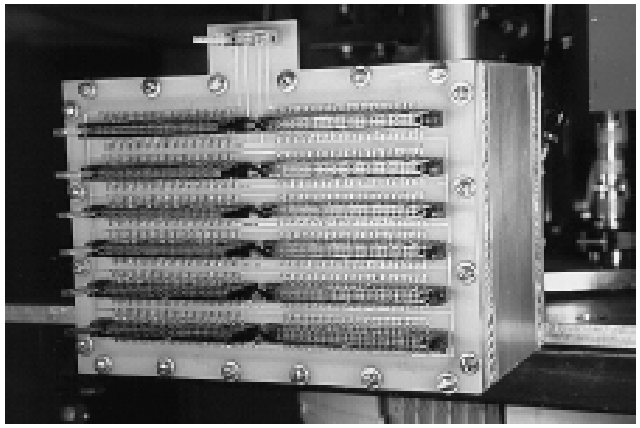




Apiezon N grease used to improve thermal contact

- Thermometer design features:
  - High sensitivity at 2 K (~ 15 Ω/mK)
  - Time response 7 ms
  - Linear response, between 1 μK – 1 K for power flux between 1 μW/cm^2 – 1 W/cm^2
  - Linear self-heating as a function of the dissipated power in the resistor (~ 1 mK for 0.2 μW)

- 2 feedthrough boxes on top of the test stand for wiring inside/outside of cryostat

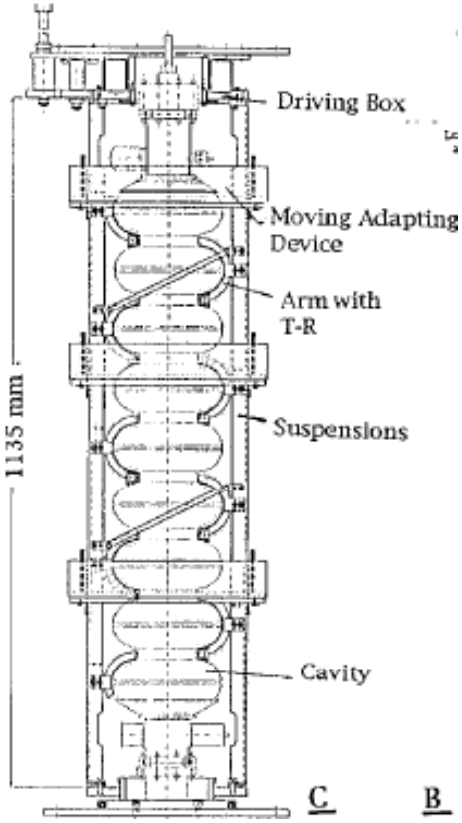


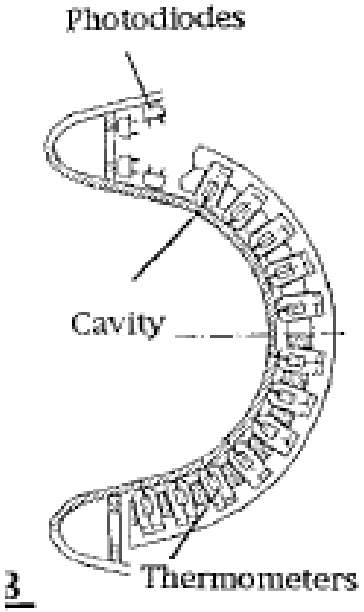
- National Instruments data acquisition system, 140ms/scan

J. Knobloch, Ph.D. Thesis, Cornell University, 1997

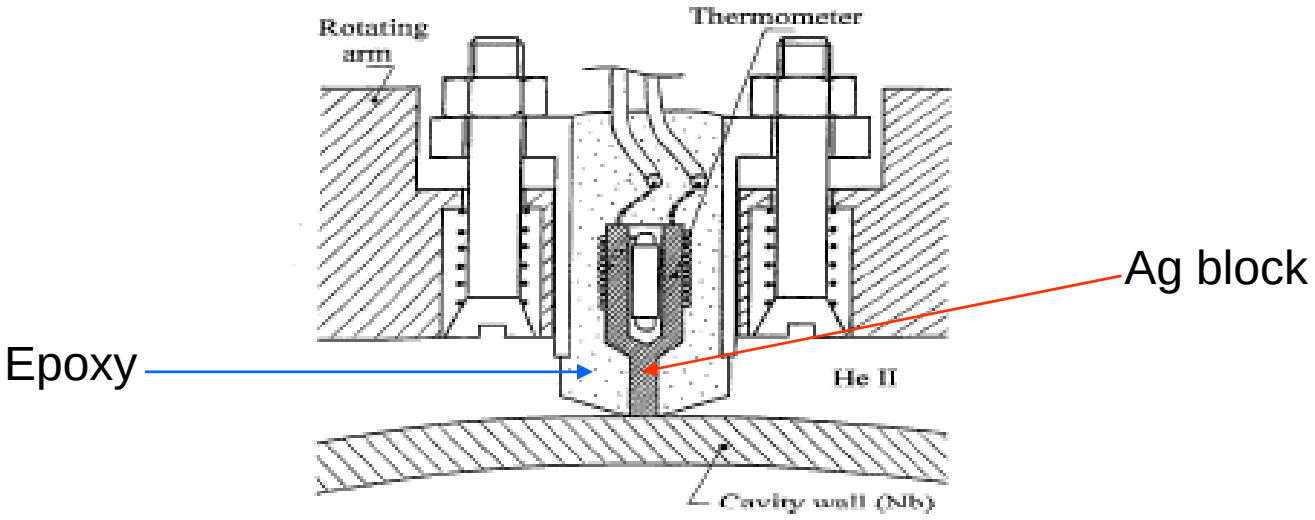
DESY 1- and 9-cell system, 1.3 GHz

- The 1-cell system is a copy of the Cornell design
- The 9-cell system is rotating, 116 thermometers distributed in 9 arms. 5° angular steps, about 1h for complete map.





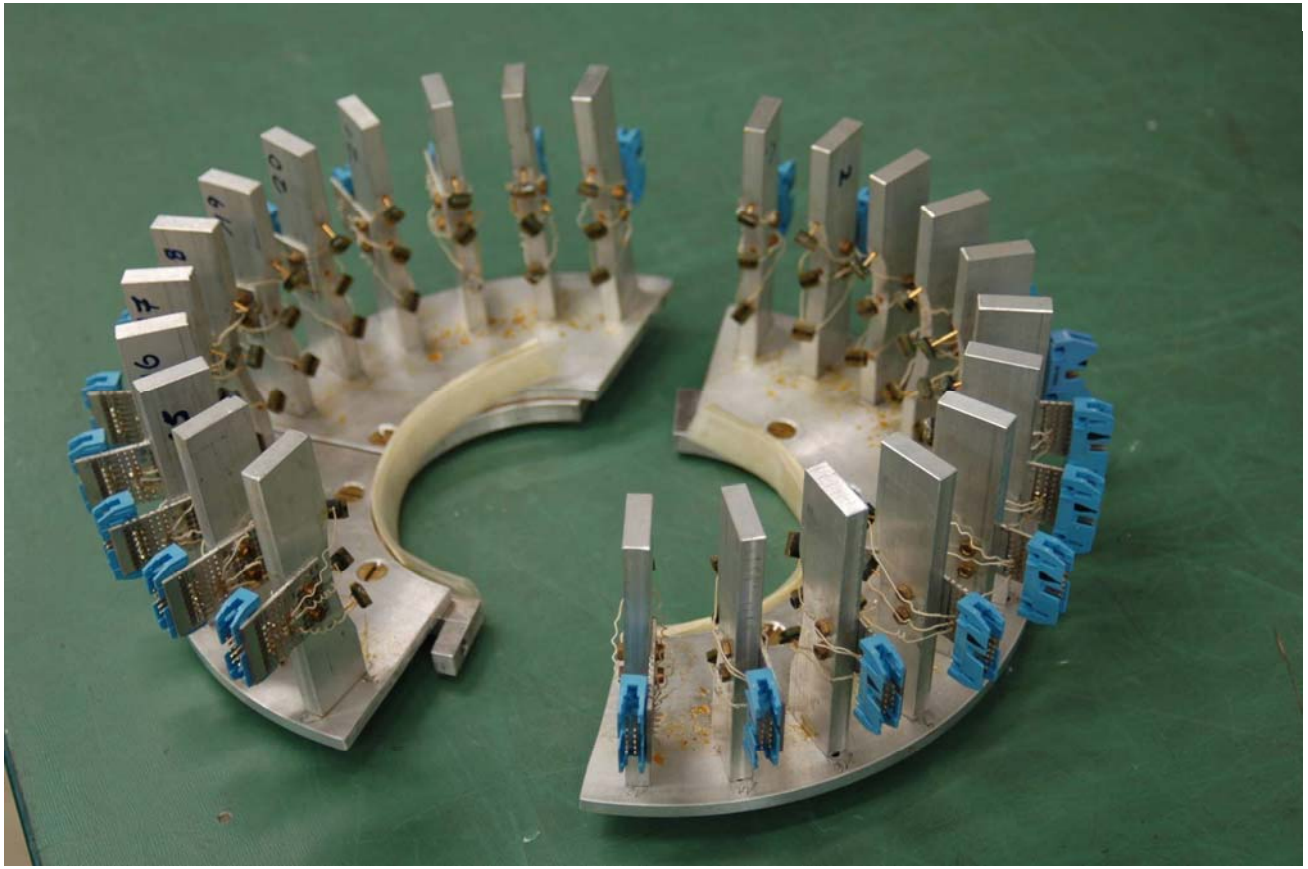
- Thermometers for rotating system:
  - 100 Ω Allen-Bradley resistors housed in a silver block, spring loaded contact
  - The thermometer efficiency depends on contact pressure and heat power level



T. Junquera et al., Proc. of the 1995 PAC, p.1648

Q. S. Shu et al., Proc. of the 1995 PAC, p.1639 and Proc. of the 7th SRF Workshop, p. 523

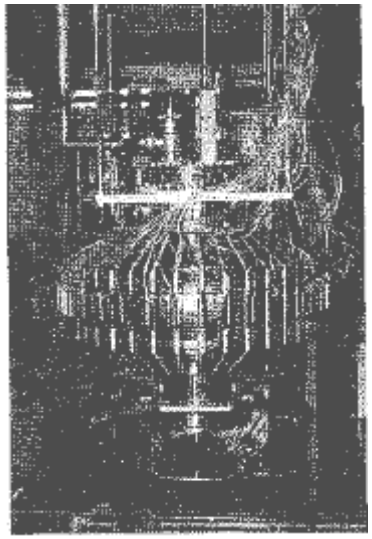
- In addition, DESY has an “equator” T-map system with Cornell-style thermometers
- 72 thermometers divided in 24 boards, 15° spaced

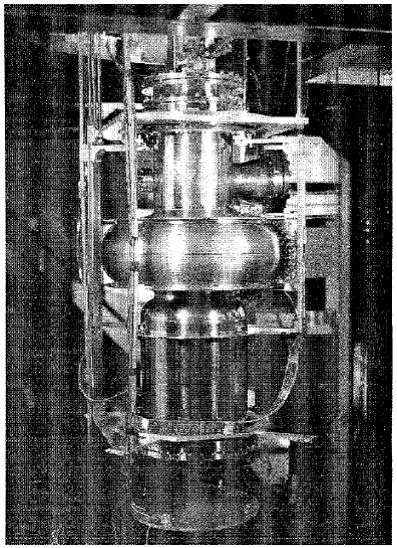


Courtesy W.-D. Moeller

KEK 1-cell systems, 0.5 GHz

- Two systems for 0.5 GHz single cells:
  - fixed, 1332 resistors (51 Ω Allen-Bradley), 36 boards, 10° spacing, 48 s/scan
  - Rotating, 25 resistors, 2 s/scan, 2-6 min/turn



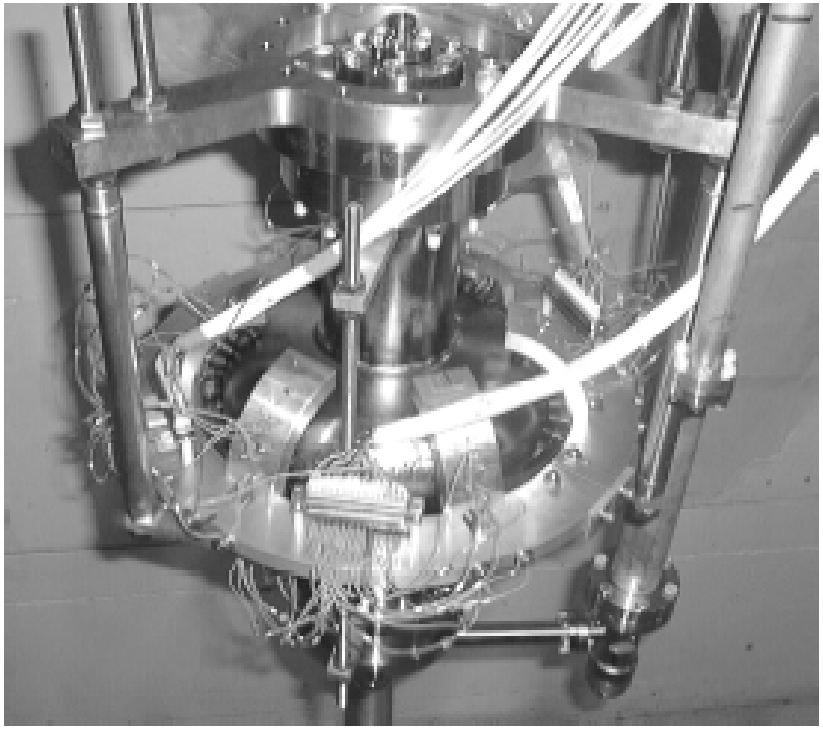


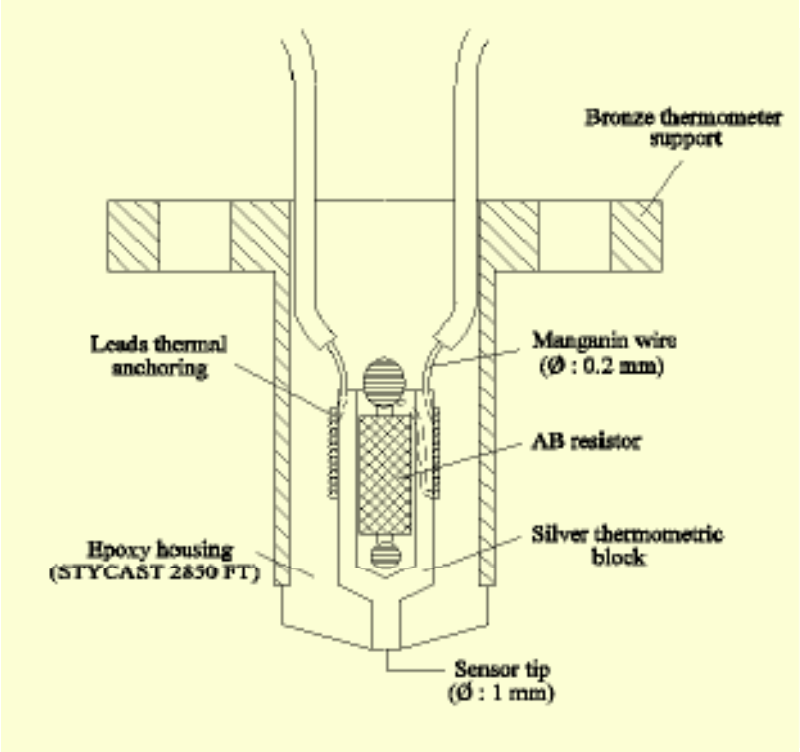
T. Takahashi et al., KEK Preprint 93-102 (1993)

T. Tajima et al., KEK Preprint 92-91 (1992)

Saclay 1-cell system 1.3 GHz

- 60 thermometers (developed for DESY 9-cell system) distributed on 6 arms, 60° spaced



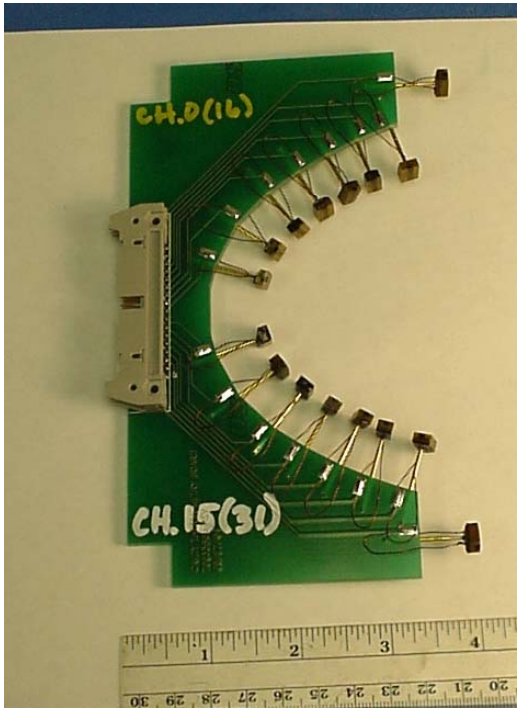


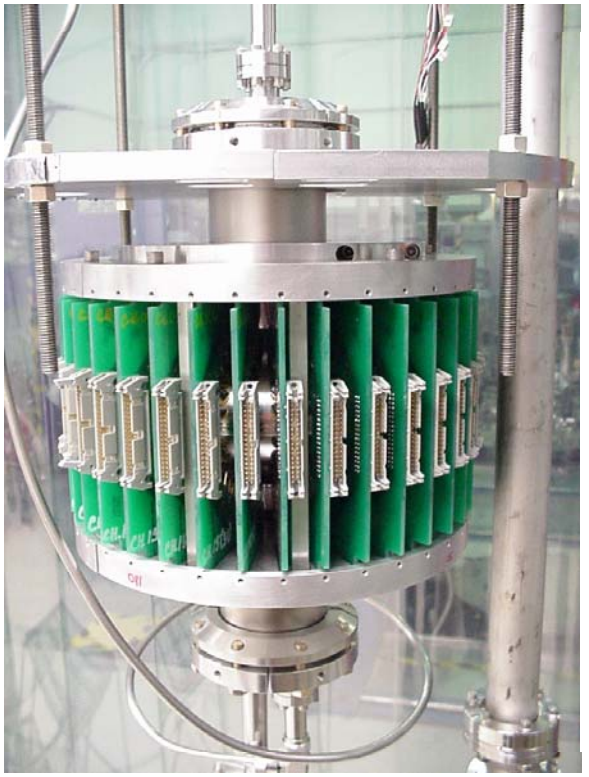
J. Lesrel et al., Proc. of the 1998 EPAC, p.1861

M. Fouaidy et al., Proc. of the 1996 EPAC, WEP043L

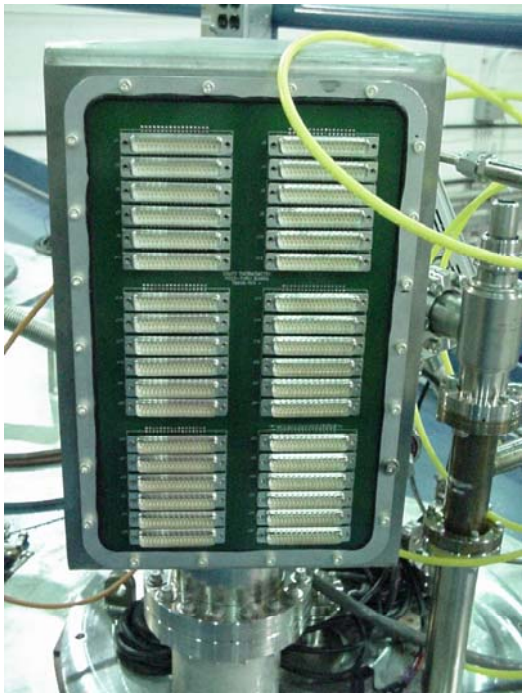
JLab 1-cell system 1.5 GHz

- Based on Cornell design. 576 resistors distributed in 36 boards, 10° spacing





- 1 feedthrough box on top of the test stand for wiring inside/outside of cryostat

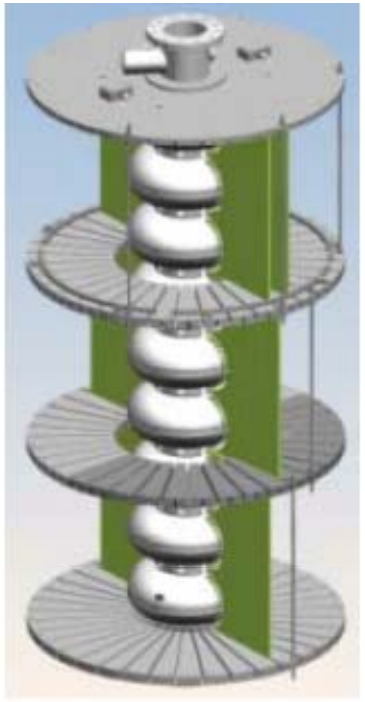


- National Instruments data acquisition system, 1MS/s, 15ms/scan

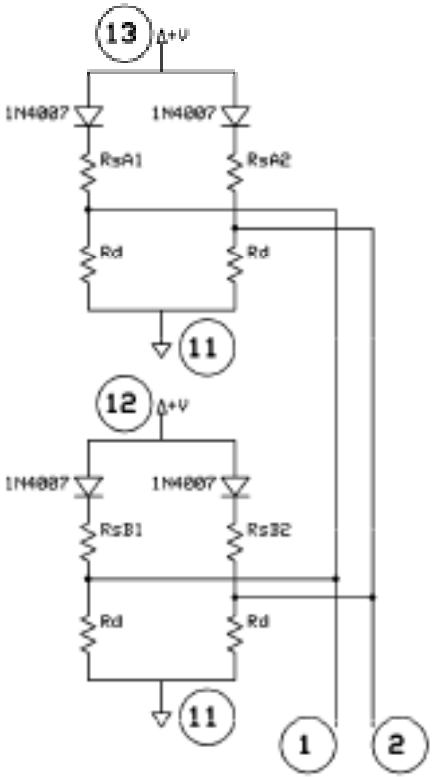
G. Ciovati et al., JLAB Tech Note TN-05-59 (2005)

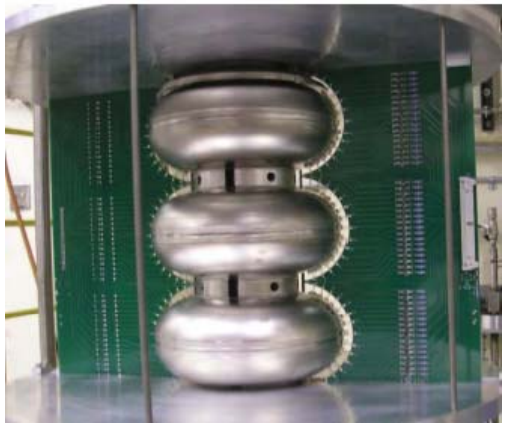
Developments

LANL 9-cell system, 1.3 GHz

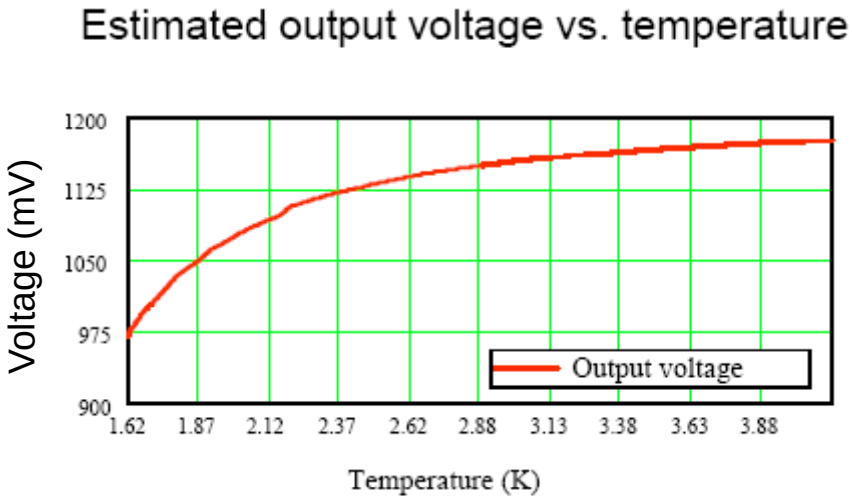


- 5508 Allen-Bradley (100 Ω)
- 15-17 sensors per meridian cell, 10° spaced
- 36 G-10 boards cover 3 cells, 108 boards total
- 12 boards (40° coverage) will be powered at a time to reduce the number of cables out of the cryostat to ~720
- Power switching done in the cryostat
- Expected ~ 2s/scan
- First test expected by 09/15/07





- The excitation voltage is multiplexed between all sensors, the readout voltage occurs on the same wire for 9 sensors

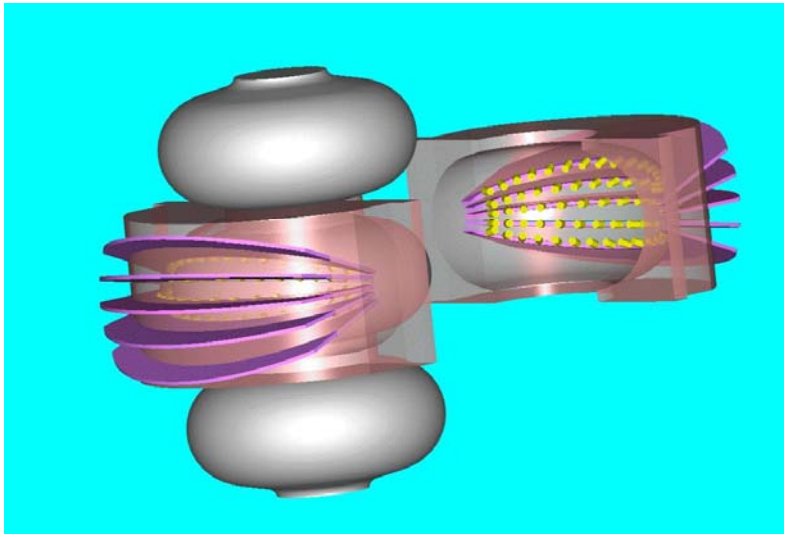


- Sensitivity at 2 K expected to be 0.186 mV/mK

A. Canabal et al., Proc. of the 2007 PAC, p. 2406

JLab 2-cell system, 1.3 GHz

- Build a system to map the equator region of 2/9 cells of ILC cavity identified as suspect for quench location by TM_{010} pass-band measurements
- Share resources (Data acquisition, software) with the existing single-cell system
- 320 Allen-Bradley (100 Ω) Cornell-style thermometers, 11° spacing, covering from weld to ~ 3 cm down along equator



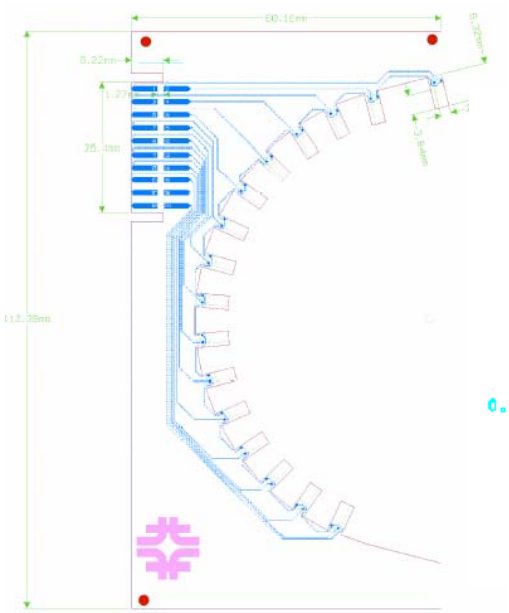
KEK 1- and 9-cell systems 1.3 GHz

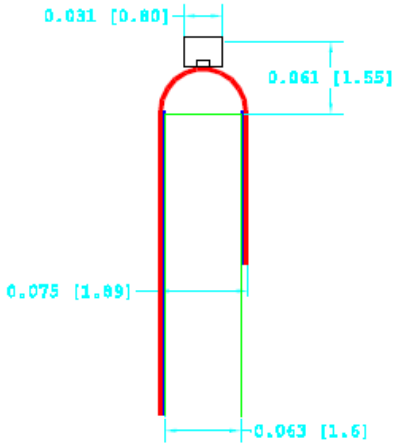
- Use RuO_2 sensors
- Make shape-independent system (film resistors)

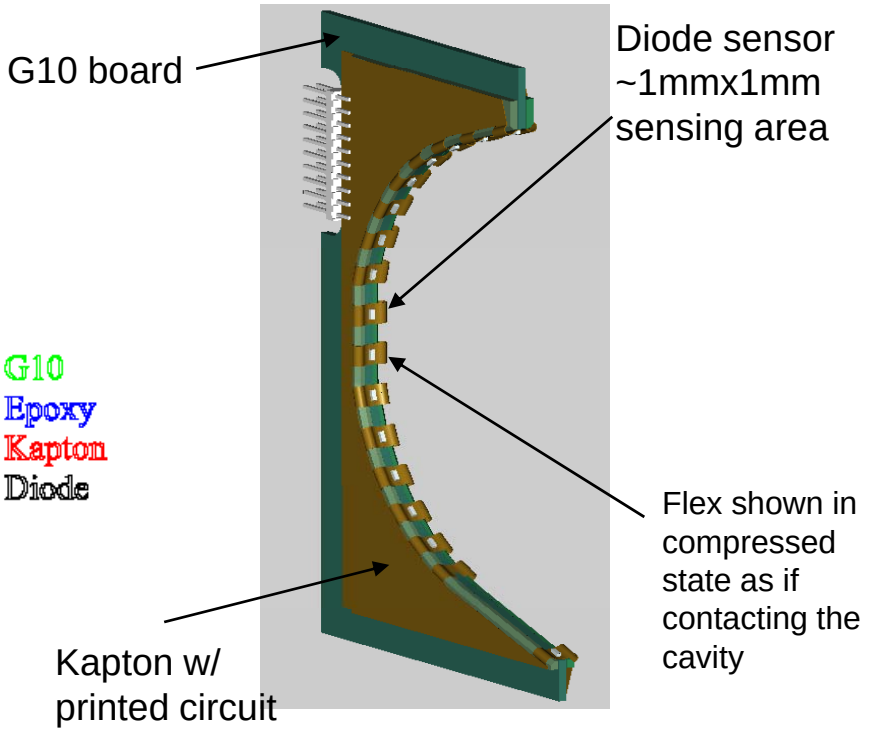
K. Saito, private communication

FNAL 1- and 9-cell system 1.3 GHz

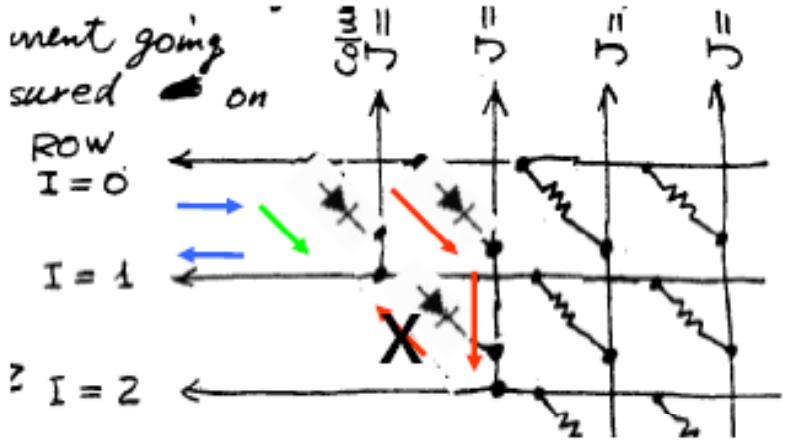
- Fixed systems, 960 diodes/cell, 16 sensors/board, 6° spacing
- Interchangeable boards between 1- and 9-cell systems



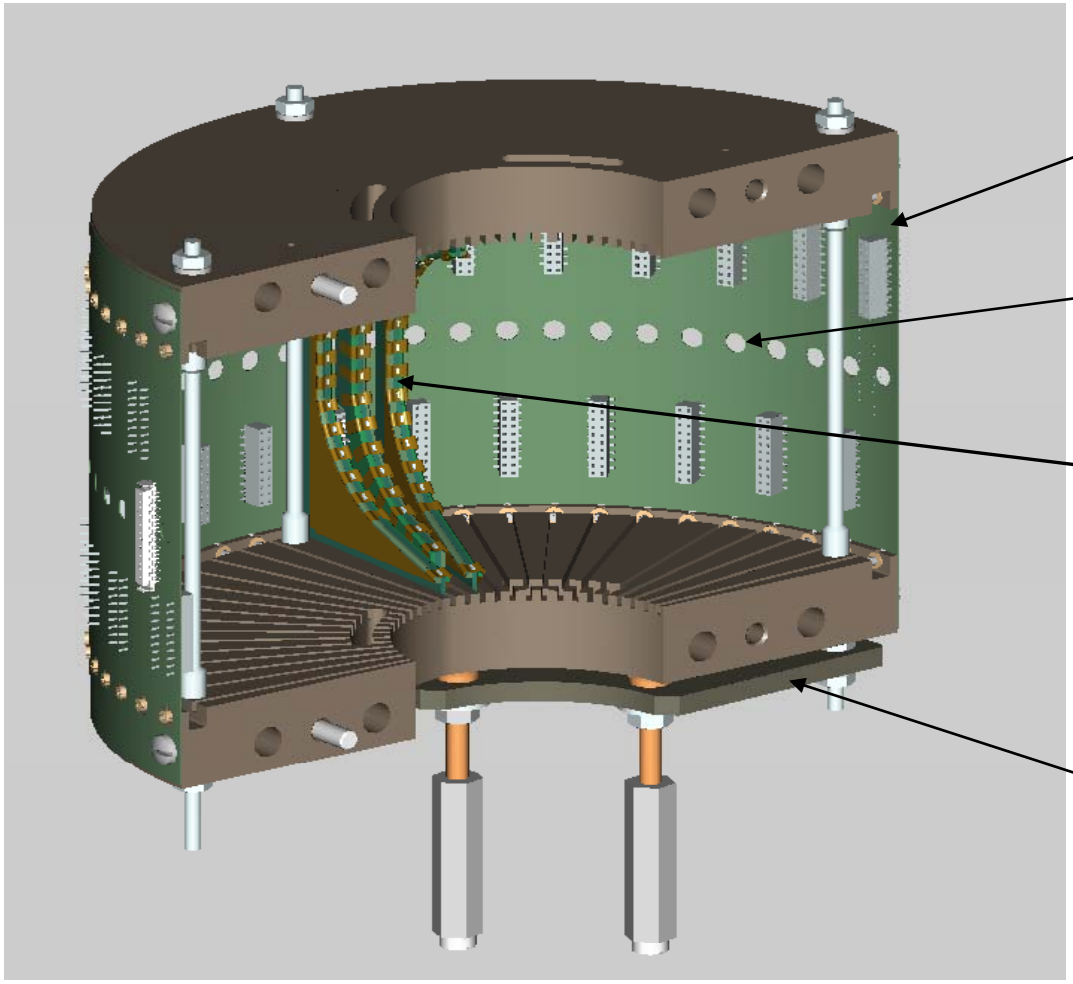




- Commercial 1N4148
  - ~ 10 mK resolution measured at 4 K
  - Temperature sensitivity (dV/dT at 2 K) and thermometer efficiency are yet to be determined
- Standard multiplexing scheme works with diodes, reduce no. of cables (one 64-pin cable/cell)



- “In house” data acquisition system
- Expected ~ 1 min/scan for 9-cell system



A. Mukherjee, private communication

Conclusions

- T-mapping is the most common diagnostic tool for SRF cavities
- In the design of new systems, fixed ones are preferred
- Systems with thousands of sensors are being built for 9-cell cavities, multiplexing schemes will be used to reduce cabling
- New sensors are being considered (RuO_2, diodes) to replace Allen-Bradley (discontinued, expensive)