Breaking and Moving Hotspots in a Large Grain Nb Cavity with a Laser Beam

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ABSTRACT

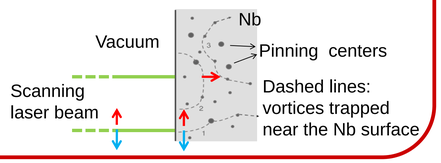
Magnetic vortices pinned near the inner surface of SRF Nb cavities are a possible source of RF hotspots, frequently observed by temperature mapping of the cavities outer surface at RF surface magnetic fields of about 100 mT. Theoretically, we expect that the thermal gradient provided by a 10 W green laser shining on the inner cavity surface at the RF hotspot locations can move pinned vortices to different pinning locations. The experimental apparatus to send the beam onto the inner surface of a photoinjector-type large-grain Nb cavity is described. Preliminary results on the changes in thermal maps observed after applying the laser heating are also reported.

OBJECTIVE

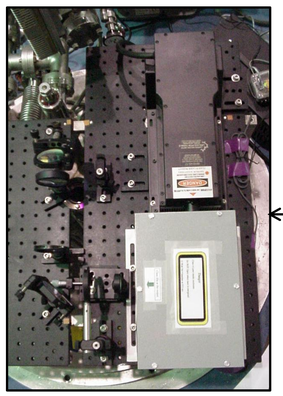
- Investigate the role of trapped vortices on RF hotspots
- Evaluate the possibility of eliminating hotspots by heating the "lossy" locations with a high power laser

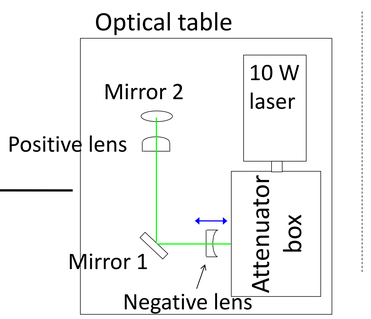
$$|\nabla T|_c = \frac{J_c}{|\partial H_{c1}/\partial T|} \cong \frac{J_c \mu_0 T_c^2}{2 B_{c1} T}$$

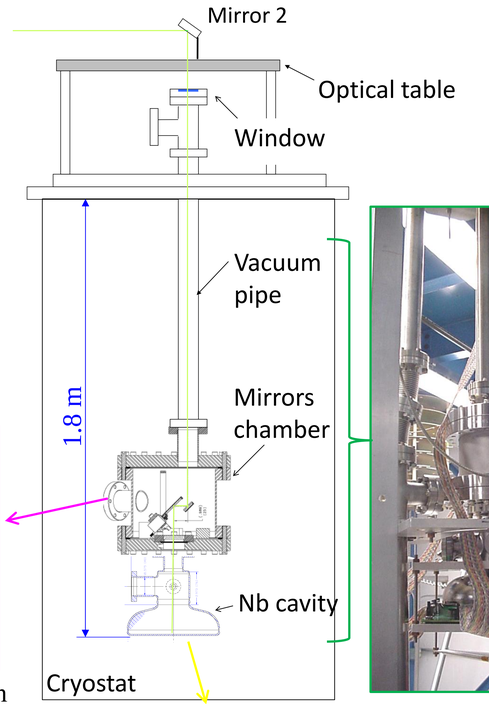
$|\nabla T|_c \approx 1.7$ K/mm



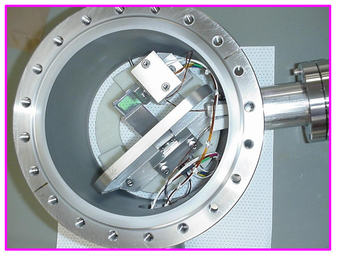
EXPERIMENTAL SETUP







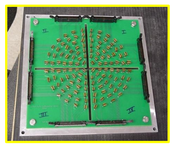
- 10 W, 532 nm solid state laser
- Positive lens: f = 305.8 mm
- Negative lens: f = -76.4 mm
- The negative lens is on a translation stage → the beam diameter on the cavity plate can be adjusted between 0.9 – 3.0 mm



2 mirrors mounted on high-vacuum stepper motors allow X-Y scanning of the beam on the cavity plate

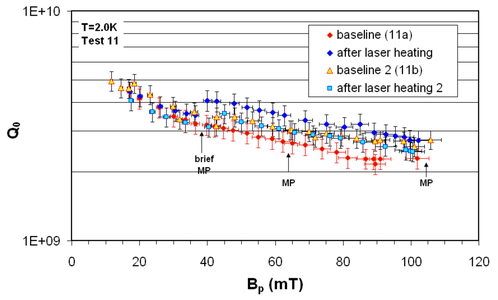
- 1.3 GHz TESLA half-cell shape
- Made of CBMM large-grain Nb
- Operating mode: TE_{011} at ~3.3 GHz

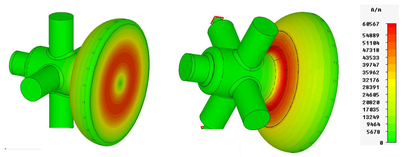
Thermometry system mounted on cavity end plate



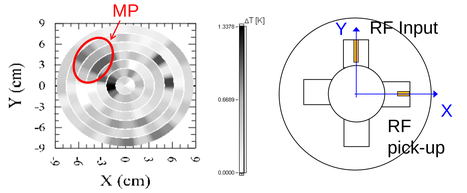
TEST RESULTS

Cavity treatment: ~80 μm BCP 1:1:2, 600 °C/10 h heat treatment, ~15 μm BCP 1:1:2





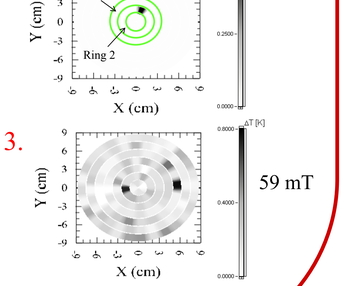
Magnetic field distribution in TE_{011} mode

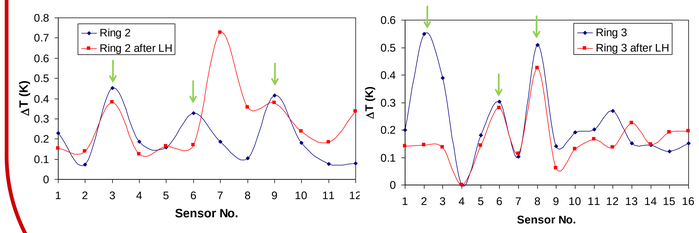


Temperature map at B_p = 102 mT (baseline test)

Test sequence at 2K:

1. Baseline RF test with T-mapping
   → Identify hotspot locations
2. Turn RF off, turn on laser and scan the beam with an outward spiral pattern from selected hotspot locations
3. Turn laser off, turn on RF and measure $Q_0(B_p)$ with T-mapping
   → Identify changes in hotspots location and intensity





Temperature distributions on rings 2 and 3 before and after laser heating at the locations indicated by the arrows, measured at B_p = 59 mT

SUMMARY and OUTLOOK

- The cavity performance is limited by multipacting at ~100 mT
- **Changes in RF heating at some hotspot locations after laser scanning suggests some of them are due to trapped vortices**
- No significant improvement in the overall Q_0 was achieved by laser scanning
  - ➢ will try different scanning patterns
  - ➢ large fraction of trapped vortices may be pinned normal to the surface
- Further experiments are planned with an auxiliary coil to generate trapped flux in the cavity

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Authored by Jefferson Science Associates, LLC under U.S. DOE Contract No. DE-PS02-09ER09-05