EXCITATION OF PARASITIC MODES IN CW COLD TESTS OF 1.3 GHZ TESLA-TYPE CAVITIES

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Abstract

The CW test of the 9 cell TESLA-type cavity in liquid helium bath at 2 K is one of the key points in the cavity procurement. This test gives the cavity performance data for the cavity acceptance. It is important to understand the error sources and precision limits for the cavity tests. The excitation of the parasitic modes in the operating pass band has been observed in 88 CW cold tests out of 182, in 42 cavities under test out of 66 since 2006. Parasitic modes excitation implies an error source for the cavity gradient and quality factor determination. The excited parasitic mode power growth rate changes significantly and depends strongly on the cavity test antenna coupling. The relation of this effect to the field emission, as well as to other test parameters has been investigated.

Introduction

TESLA-type cavities are tested in the vertical cryostat at 2 K in CW condition before the string of 8 cavities is mounted in the cryogenic-module. All 9 modes of the TM010 pass band are measured for the investigation of cell differences. The excitation of parasitic modes is observed during CW cold cavity tests. The determination of the cavity gradient and the quality factor contains errors when the generation of additional modes starts (Fig. 1) because the power meter measures two modes together.

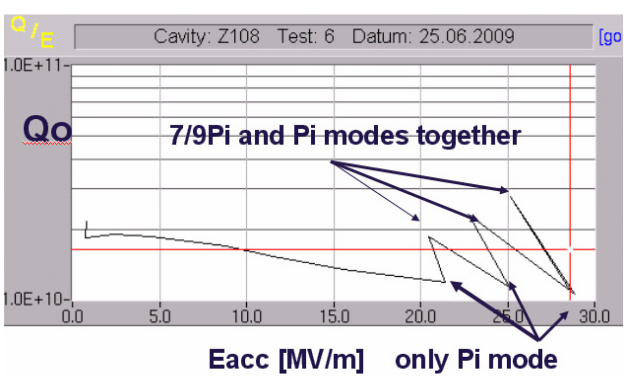

Figure 1: An excitation of 7/9Pi mode changes Qo and Eacc

Sometimes the big amplitude of the parasitic mode destroys the frequency lock and interrupts the RF measurement. The parasitic generation is detected by the Spectrum Analyzer (Fig. 2) connected to the pickup antenna. Determination of the nature of modes generation is our aim.

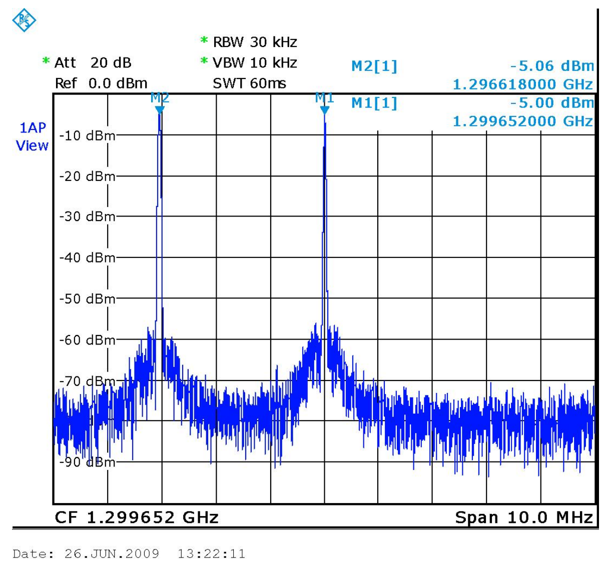

Figure 2: Pi-mode and parasitic 7/9Pi are separated by the spectrum analyzer connected to the pickup antenna.

Statistics

The excitation of the parasitic modes in the operating pass band TM010 has been observed in 88 CW cold tests out of 182 and in 42 cavities under test out of 66 since 2006. Pi, 2/9Pi and 6/9Pi modes excite frequently other parasitic modes frequently other modes. Main trouble is the appearance of 7/9Pi mode from Pi mode:

- This mode is built up in almost all best cavities with high Q.
- The 7/9 Pi mode makes big errors of Eacc and Qo measurements of Pi mode.
- High amplitude of the 7/9 Pi mode unlocks the drive frequency of Pi mode.

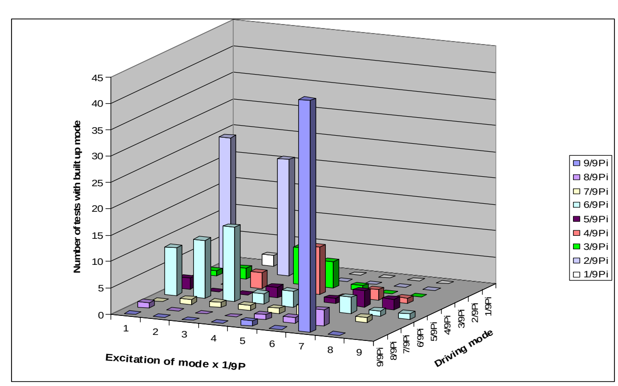

Figure 3: The excitation of the parasitic modes in 182 CW cold tests since 2006.

The histograms (Fig. 4), (Fig. 5) and (Fig. 6) show the number of cold tests and the Eacc in the cell #9 measured by the pick up probe when the mode excitation starts.

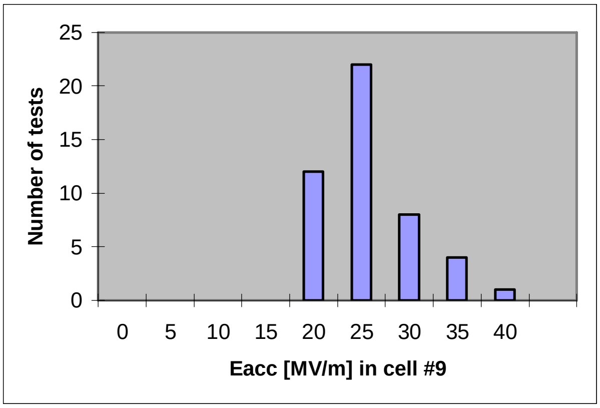

Figure 4: Excitation of 7/9 Pi mode from Pi mode.

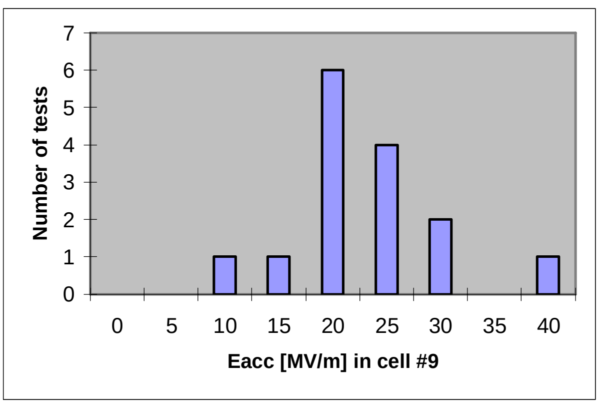

Figure 5: The mode excitation from 6/9 Pi mode. The mode excitation from 6/9 Pi and Pi modes starts at a high gradient. 6/9Pi mode builds up 2/9, 3/9 and 4/9Pi modes. Instability takes place by increasing power of 6/9Pi mode.

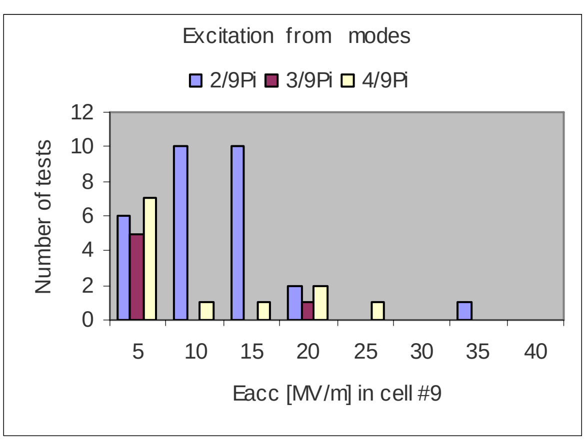

Figure 6: Mode excitation from 2/9 Pi, 3/9 Pi and 4/9 Pi modes.

Correlation to the Radiation

The Radiation is measured by the sensor placed at the top, outside of the cryostat.

- Mode generation from 6/9 Pi mode is accompanied by strong radiation (Fig. 7).
- 7/9 Pi mode is generated by Pi mode without the radiation measured outside of the cryostat in many cold tests (Fig. 8).

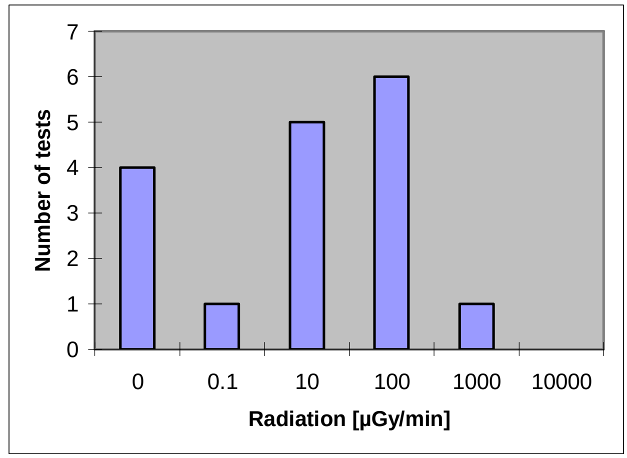

Figure 7: Mode generation from 6/9Pi mode vs. radiation.

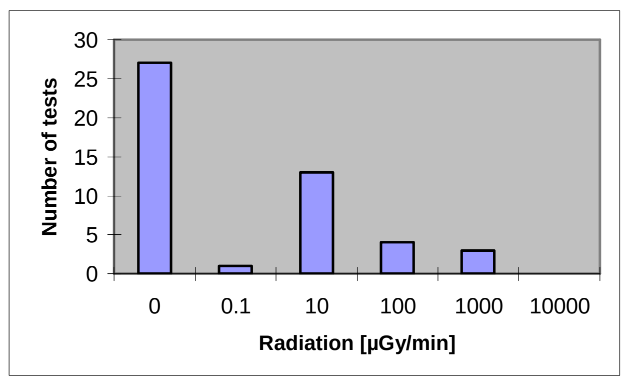

Figure 8: 7/9Pi mode generation from Pi mode vs. radiation.

The Radiation in the Cryostat

In order to investigate the radiation not only at the top plate of the cryostat TLD thermo-luminescent detectors were placed on the cavity tank. A cavity without any radiation measured outside the cryostat was used. Low energy radiation < 50 kV was measured by sensors after 3 hours exposition at a field of 23-25 MV/m. One test was done without parasitic mode. Then the sensors were replaced and the second test was done with 7/Pi-mode excitation. The generation of parasitic mode changed the radiation distribution (Fig 9). The radiation had low energy because it was attenuated about 2 to 4 times by the cavity tank wall (5 mm titanium).

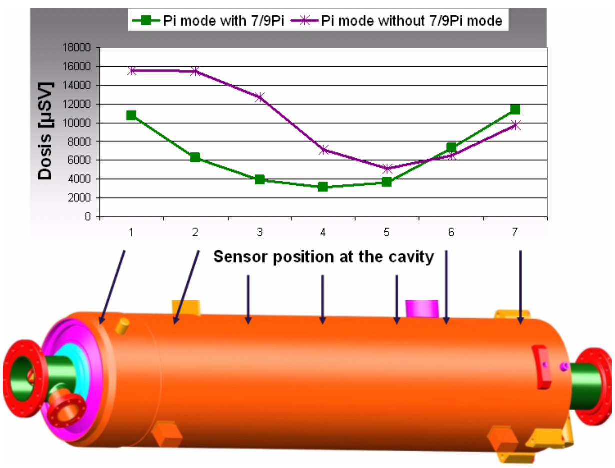

Figure 9: Generation of parasitic 7/9 Pi mode changes the radiation. Amplitude of 7/9 Pi mode is -3 dB to Pi mode. Exposition: 3 hours in each cold test.

The Excitation Function

- The ramp of the mode excitation depends strongly on the Qload changing by the input antenna coupling. The ramp of the excitation is higher when the Qload is larger (Fig 8).
- The exponential function of the parasitic mode excitation exp(t/T) is different from the cavity pulse response 1- exp(-t/T).
- The exponential function exp (t/T) describes a positive feed-back system.
- The dependence of the mode excitation from Qload and positive feed-back characteristic has a good agreement to KEK theory [1] with the field emission. The measurement of the radiation in the cryostat confirmed the field emission in the cavity.
- Disagreement to the field emission theory is large power (30 W) transmitting to parasitic mode without additional losses from the emission current.

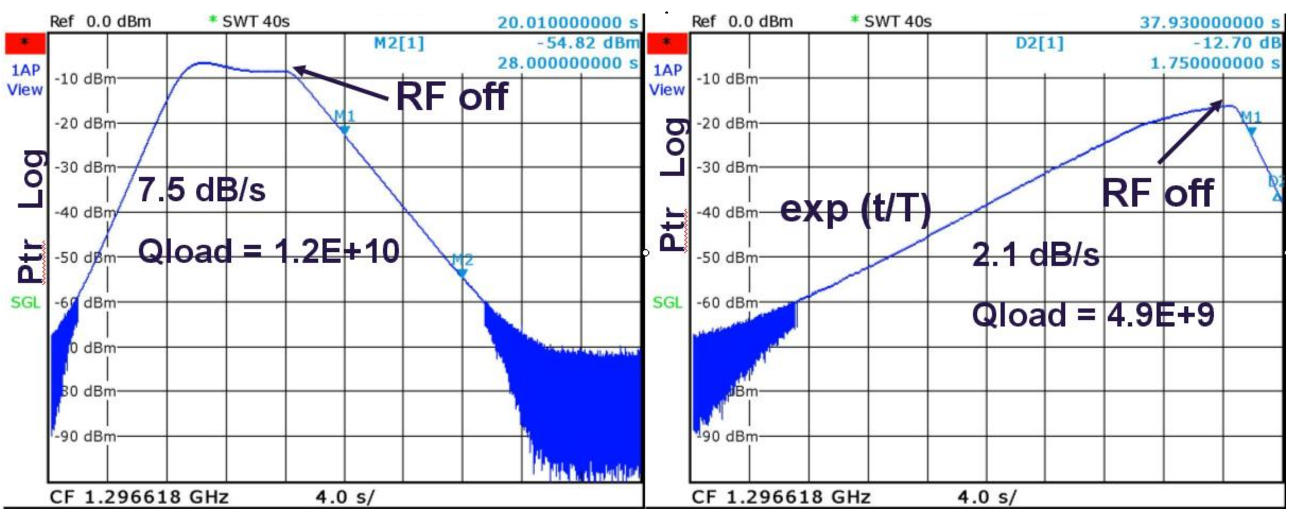

Figure 10: Excitation function is positive exponent exp (t/T) and can be from the positive feed-back. Excitation is faster for larger Qload

Summary

Drive mode Pi excites parasitic mode 7/9Pi:

- Errors in Qo and Eacc measurement.
- The excitation is stable, has large amplitude and sometimes destroys the lock of the Pi mode.
- The power transmission to the 7/9Pi mode does not make any additional losses.
- The mode excitation depends strongly on the Qload.
- The exponential function of the parasitic mode excitation is formed by positive feed back.
- Field emission exists in the cavity.
- Large power transmits to the parasitic mode without additional losses.

Drive modes other than Pi:

- Most of parasitic modes are unstable and have low fields.
- Excitation is accompanied by a strong field emission

REFERENCES

[1] S.Noguchi. Parasitic Mode Excitation. TTC Meeting Orcay (2009).