RRCAT processing and test experiences

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Introduction to RRCAT VTS and HTS facilities

The Vertical Test Stand (VTS) at RRCAT was commissioned in 2014, and since then it has been in used along with several upgrades, based on the operational experience. The RF system of the facility was developed in collaboration with FNAL. Till date, we have tested single cell 1300 MHz and 650 MHz cavities, and 5-cell 650 MHz (Beta 0.92).

The first successful test at RRCAT VTS was conducted on 31 Jan 2014 on a single cell 1.3 GHz cavity (TE1CAT004) which was previously tested at FNAL and was provided to us in sealed condition for benchmarking our facility.

Till date six RRCAT fabricated and processed, 5-cell 0.92 Beta Cavities, have been qualified at RRCAT VTS. The maximum gradient in our tests was 29 MV/m by cavity B92-RRCAT-505

RRCAT has one operational VTS cryostat and provision for another cryostat. At present we have three independently operatable inhouse developed RF system for VTS (critically coupled cavities). One of which is installed in the HTS facility and can be used to test critically coupled cavities in HTS. **Presently our RF system are capable of handling 650 MHz, 1300 MHz and 325MHz structures.**

Recently RRCAT HTS facility was also commissioned with Fermilab loaned AES010 cavity. The facility has been operated thrice so far with the AES010 cavity, the test results at RRCAT HTS are comparable to the one reported by Fermilab.

The LLRF and RFPI system for the HTS facility have been developed by BARC. Machine Protection System, 36 kW SSPA and cryogenic system is developed by RRCAT.

Introduction to RRCAT VTS facility

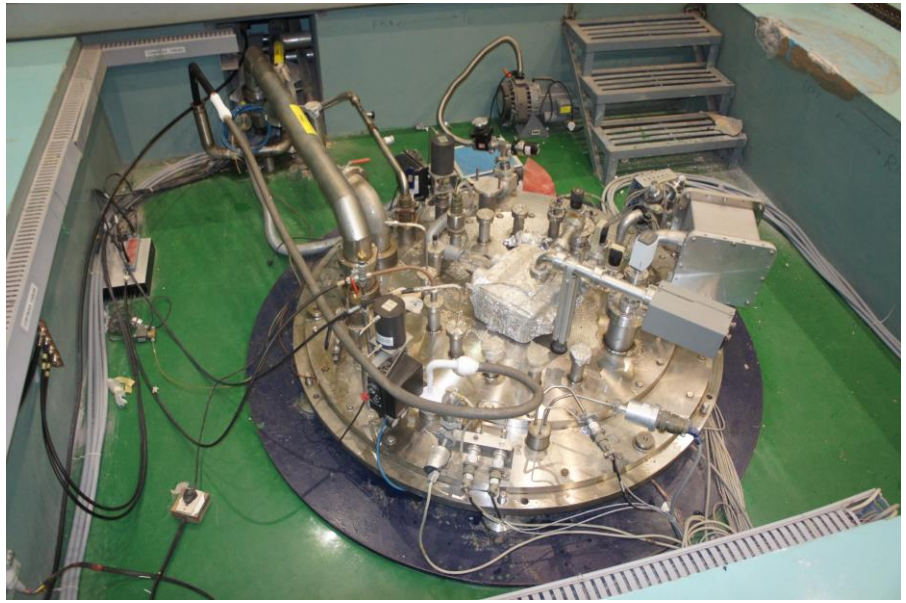
The left image shows the two LLRF system installed at VTS facility in RRCAT.

Right image is of similar system installed at HTS facility, where it was used during commissioning trials of the HTS facility.

An in-house developed 650 MHz, 350 W SSPA is used in the above RF systems and can provide close to 200 W of CW power to the cavity.

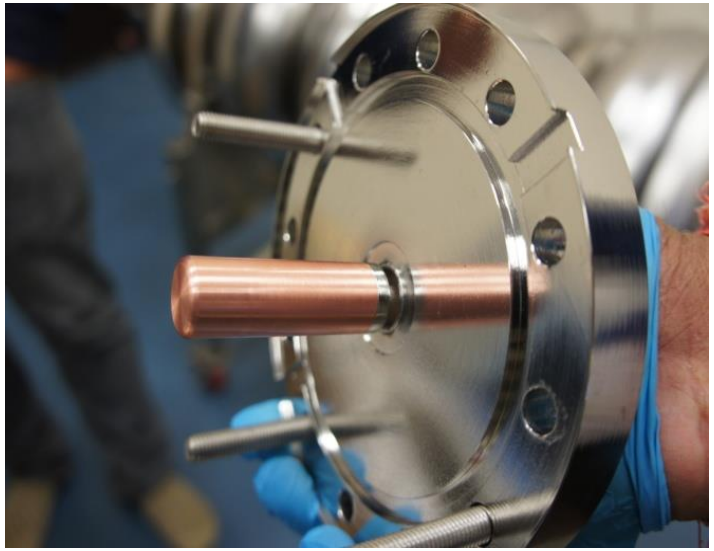
Since at RRCAT team which developed the RF system is the same as the operational team the system is continuously being improved upon with experience gained.

Introduction to RRCAT VTS facility



Cold Testing Procedure at RRCAT

After final tuning of the cavity the pickup and fundamental power coupler quality factor are measured and optimized. At present we keep FPC at ~ $1x10^{10}$ to $2x10^{10}$ and pickup coupler at ~ $2x10^{12}$ to $3x10^{12}$ for 650 MHz cavities. The cavity is then sent for further processing.



After final processing, the cavity is inserted in the Vertical Test Stand. The resonant frequency and through loss of the cavity are then remeasured and compared with the expected loss based on coupler measurements. This step is needed to ensure that RF connections are OK before cooldown.

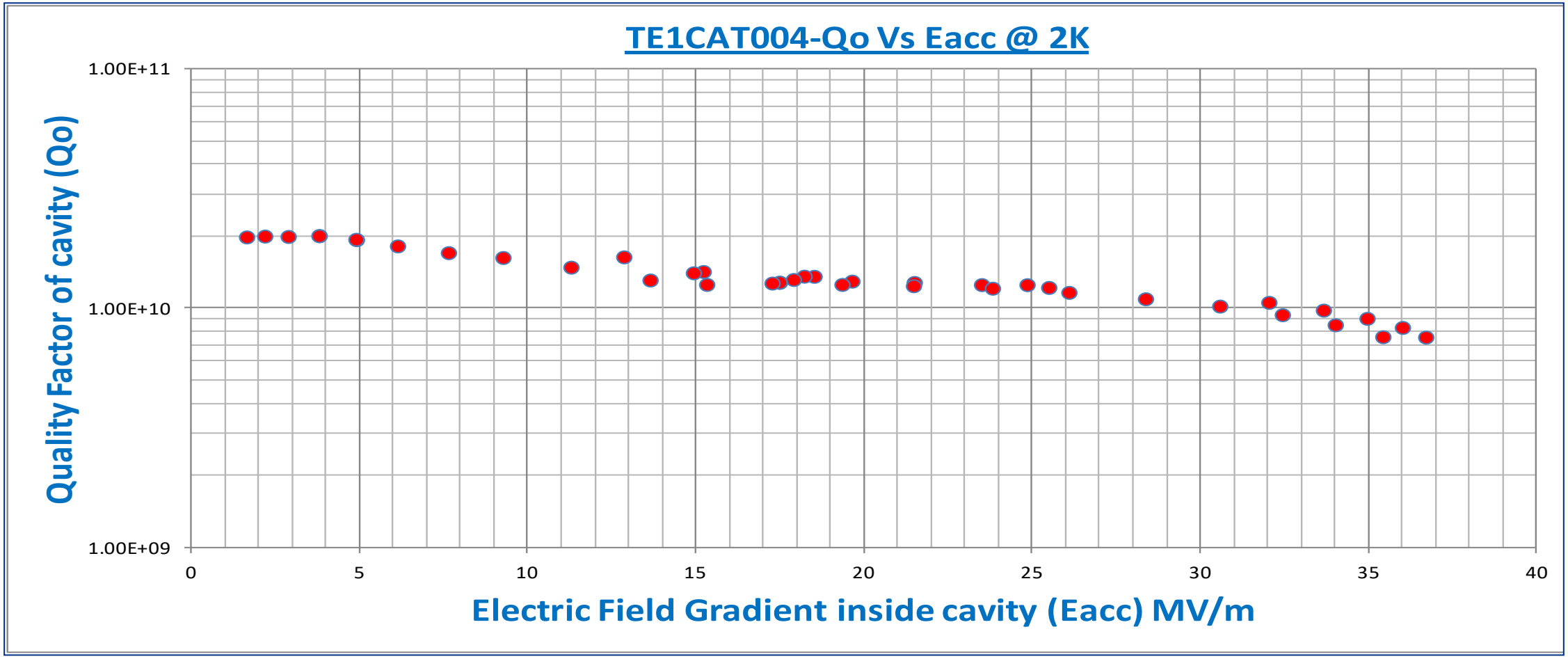
Cold Testing Procedure at RRCAT

When cavity is fully immersed in the liquid Helium, cold testing of the cavity is first conducted at 4.2K. The test is conducted to verify the functioning of the LLRF system, amplifier and the interconnects. It is needed since presently few tests are being conducted per year at RRCAT and significant gap can occur between two cold tests.

After the 4.2K test, pumping is done to reach 2K at which resonant frequencies for all the modes are recorded, followed by cable calibration and decay measurement to identify Q_{ext2}. After the decay measurements under/over coupling is verified. External radiation shield is then moved to its place after which, testing is first done with 1 W amplifier and then with the high-power amplifier.

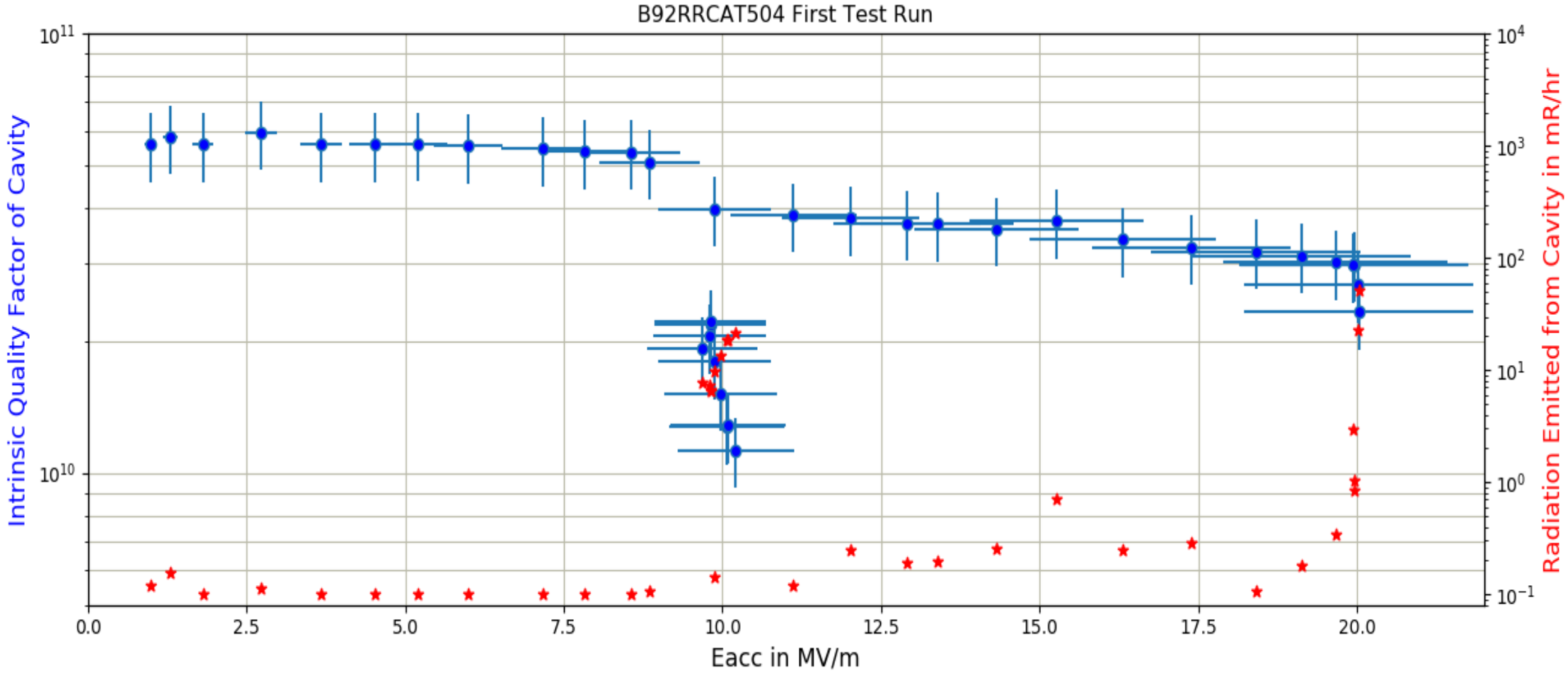
At present we are using SiO_2 based half (1/2) inch cable assembly for incident power, incident cable loss is calibrated several times during the test with changes in the power level.

Our first successful test at RRCAT VTS conducted on 31 Jan 2014 on a single cell 1.3 GHz cavity (TE1CAT004)



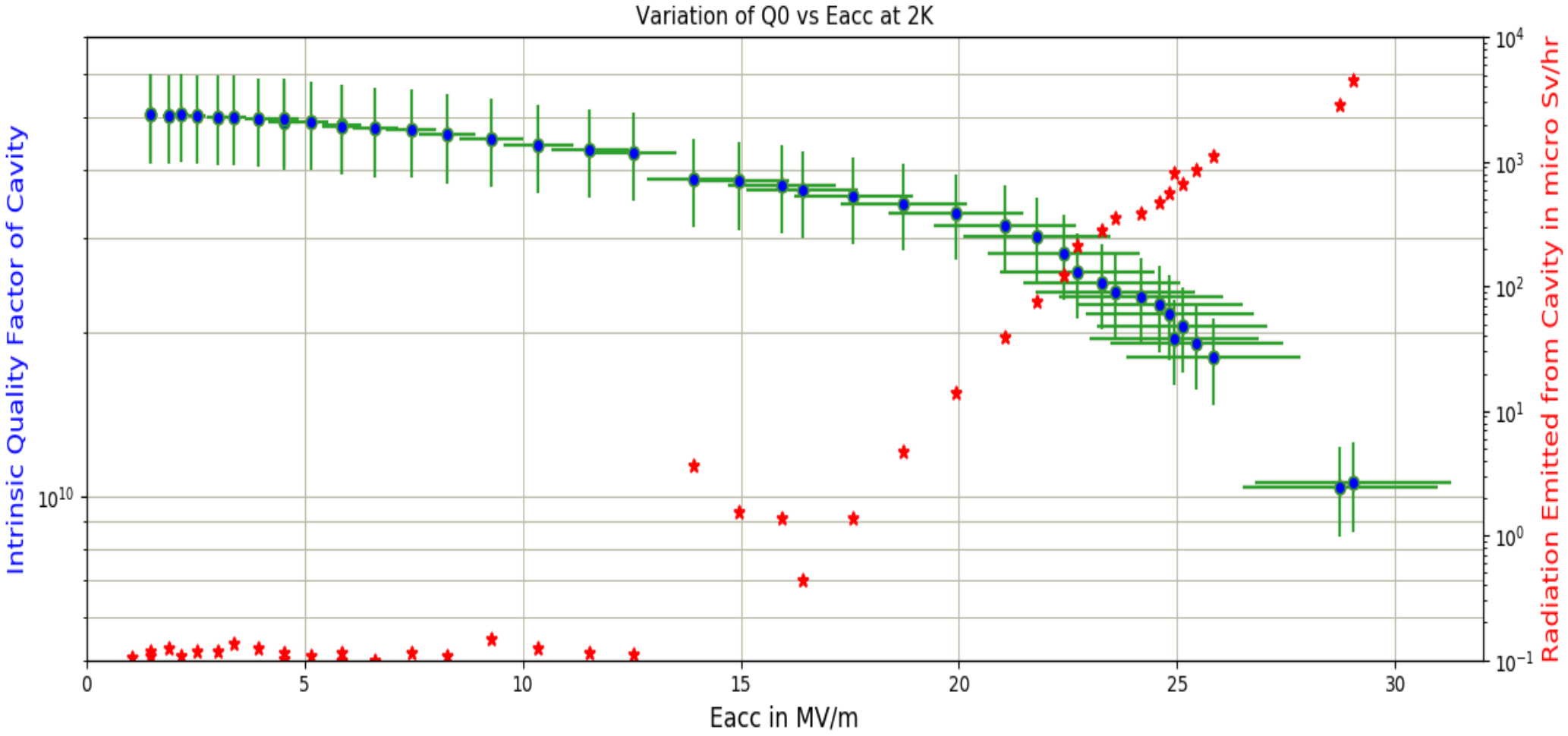
Test result of 504 cavity in Aug 2020

First time we reached 20MV/m



Test result of 505 cavity in Nov 2020

Highest Gradient achieved at RRCAT VTS



Thanks