

Research and development of 650 MHz superconducting cavity for CEPC

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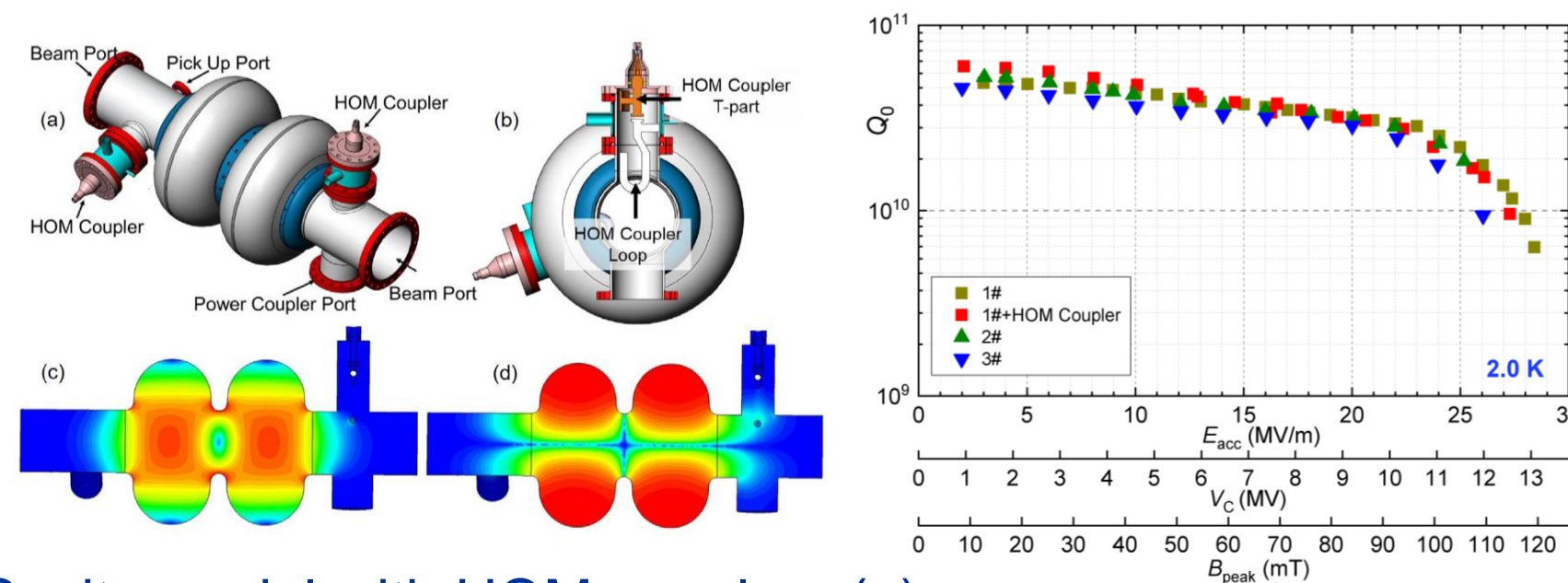
Abstract

The 650 MHz superconducting radio-frequency (SRF) cavities used for the Circular Electron Positron Collider (CEPC) were studied to achieve high accelerating gradient (E_{acc}) and high intrinsic quality factor (Q_0). The 650 MHz single-cell cavities were subjected to a combination of buffered chemical polishing (BCP) and electropolishing (EP), and their E_{acc} exceeded 40 MV/m. Such a high E_{acc} may result from the cold EP with more uniform removal. BCP is easy, cheap, and rough, whereas EP is complicated, expensive, and precise. Therefore, the combination of BCP and EP investigated in our study is suitable for surface treatments of mass SRF cavities. Medium temperature (mid-T) furnace baking was also conducted, which demonstrated an ultrahigh Q_0 of $> 8E10$ at 22 MV/m, and an extremely low BCS resistance of ~ 1.0 n Ω was achieved at 2.0 K. Moreover, nitrogen doping was carried out, which also enhanced Q_0 of 650 MHz SRF cavities.

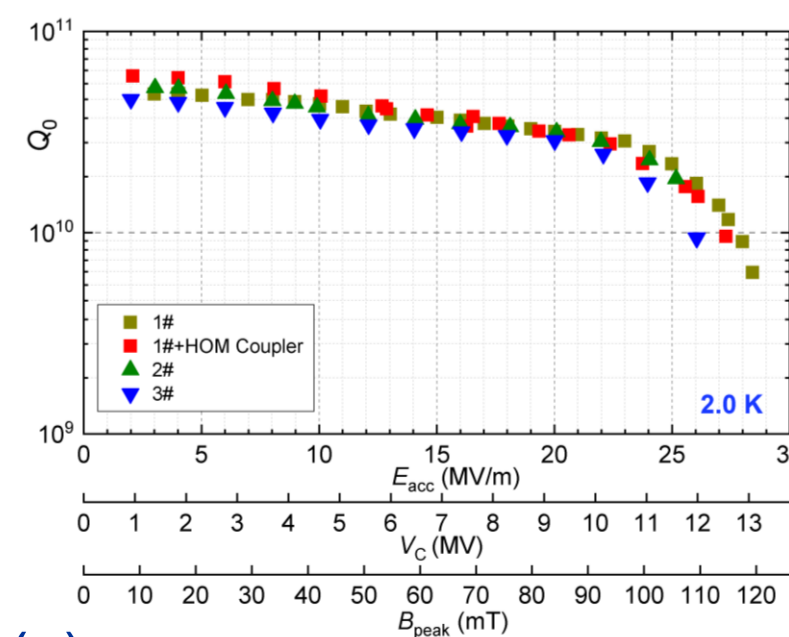
650 MHz two-cell

Three 650 MHz 2-cell cavities were fabricated, buffered chemical polished (BCP) and tested, which all exceeded $3E10@20MV/m$. More details:

- a) *Nuclear Inst. and Methods in Physics Research, A 995 (2021) 165093*, <https://doi.org/10.1016/j.nima.2021.165093>
- b) *Nuclear Inst. and Methods in Physics Research, A 1031 (2022) 166590*, <http://dx.doi.org/10.1016/j.nima.2022.166590>



Cavity model with HOM couplers (a) and the profile from power coupler side (b) and the electric (c) and magnetic (d) field distribution

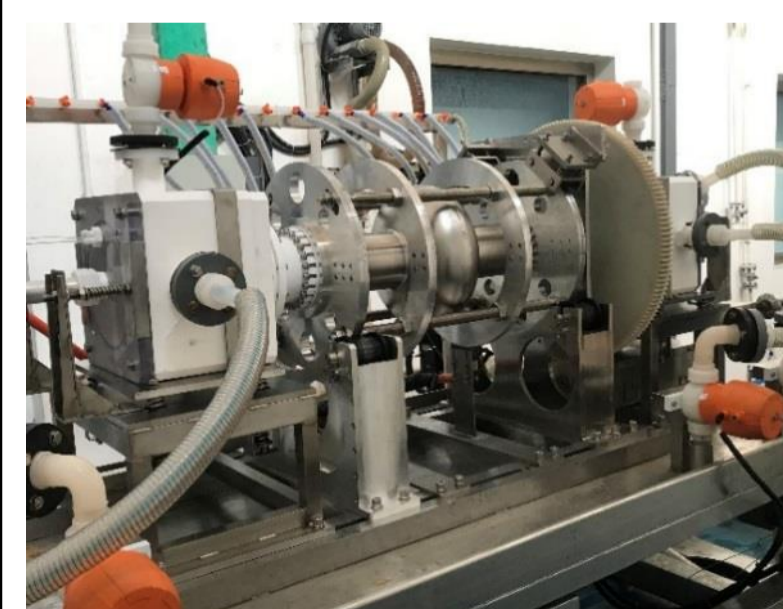


Vertical test results

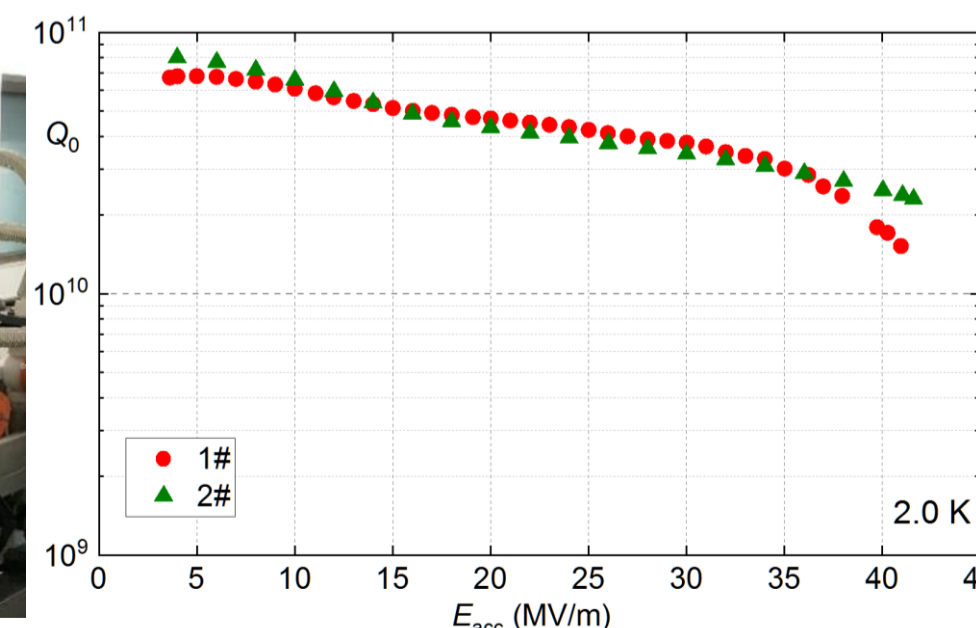
High E_{acc} 650 MHz single-cell

The research of electro-polishing (EP) at 650 MHz single-cell cavity have been carried out, which enhanced E_{acc} greatly. The vertical test results (@ 2.0 K) indicated that the maximum E_{acc} of both the two cavities reached 41.0 and 41.6 MV/m, respectively. More details:

- a) *Nuclear Science and Techniques, 33, 125 (2022)*, <https://doi.org/10.1007/s41365-022-01109-8>



EP of 650 MHz single-cell



Vertical test results after EP process

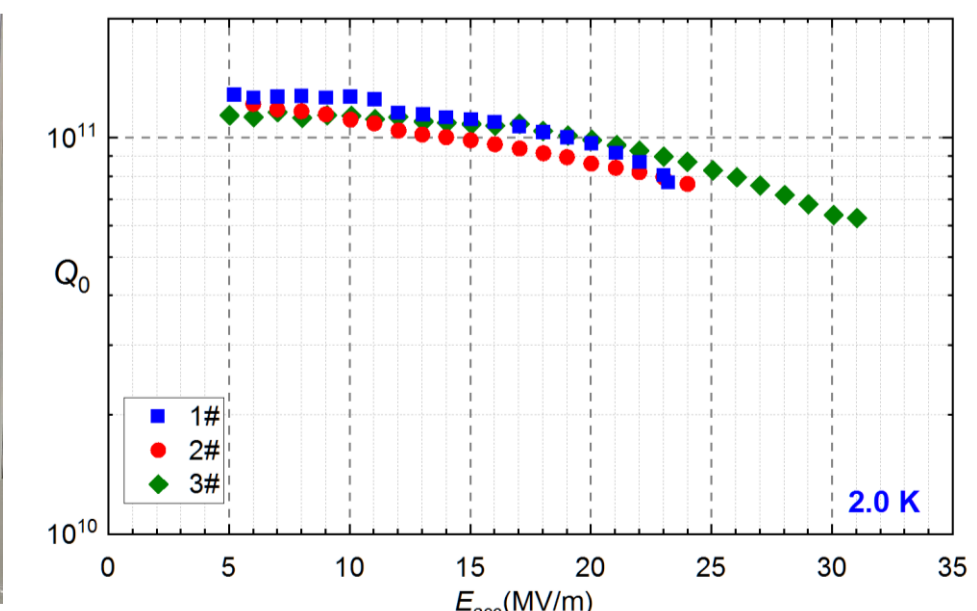
High Q_0 650 MHz single-cell

The research of mid-T furnace baking at 650 MHz single-cell cavity have been conducted, which improved Q_0 greatly. The vertical test results (@ 2.0 K) indicated that all the three cavities demonstrated extremely high Q_0 , which exceeded reached 8×10^{10} @ 22 MV/m. More details:

- a) *IEEE Transactions on Applied Superconductivity, Volume: 34, Issue: 1, January 2024*, <https://doi.org/10.1109/TASC.2023.3332510>



Mid-T furnace baking of 650 MHz single-cell



Vertical test results after mid-T furnace baking