Contribution ID: **1051** Contribution code: **TUPS155** Type: **Poster Presentation**

Multi-physics analysis of a 280 MHz superconducting radio-frequency quadrupole test cavity

Tuesday 3 June 2025 16:00 (2 hours)

Superconducting(SC) radio-frequency(RF) quadrupole (RFQ) integrates the high efficiency of SC technology with the strong focusing and stable acceleration capabilities of RFQ .It is a critical development in next-generation high-performance accelerators.In this study, we present the multi-physics analysis results of a SC RFQ test cavity operating at a frequency of 280 MHz. This test cavity is designed to be a constant voltage of 240 kV and can be used to accelerate a 10 mA proton beam. The RF design adopts a four-vane structure, which is both structurally stable and facilitates efficient liquid helium cooling. Multi-physics analysis indicates that the cavity deformation and thermal stress meet the operational requirements after the post-treatment of the electrodes.The SC RFQ holds significant potential in many areas, including medical isotopes,particle physics experiments,Boron Neutron Capture Therapy (BNCT) and Proton Therapy. Because of the low operational costs and compact structure, it provides an possibility to enable industrialization and applications of high-power accelerators.

Footnotes

Paper preparation format

Word

Region represented

Asia

Funding Agency

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Session Classification: Tuesday Poster Session

Track Classification: MC4: Hadron Accelerators: MC4.A08 Linear Accelerators