COMPACT PROTON ACCELERATOR IN UHF-BAND AT KAHVELab

LINAC2022 LIVERPOOL

August 28, 2022

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Proton Test Beam at KAHVELab (Kandilli Detector, Accelerator and Instrumentation Laboratory) project aims to design and produce a radio frequency quadrupole (RFQ) operating at 800 MHz in Istanbul, Turkey using the local resources. The beamline consists of a proton source, a low energy beam transport (LEBT) line including the beam diagnostic section and the RFQ cavity itself. This RFQ is 4-vane, 1-meter-long cavity to accelerate the 20 keV beam extracted from plasma ion source to 2 MeV. Its engineering prototype is already produced and subjected to mechanical, low power RF and vacuum tests. In this poster, the results of the first test production, especially the bead-pull test setup will be discussed.

This project are supported by TUBITAK Project no: 118E838

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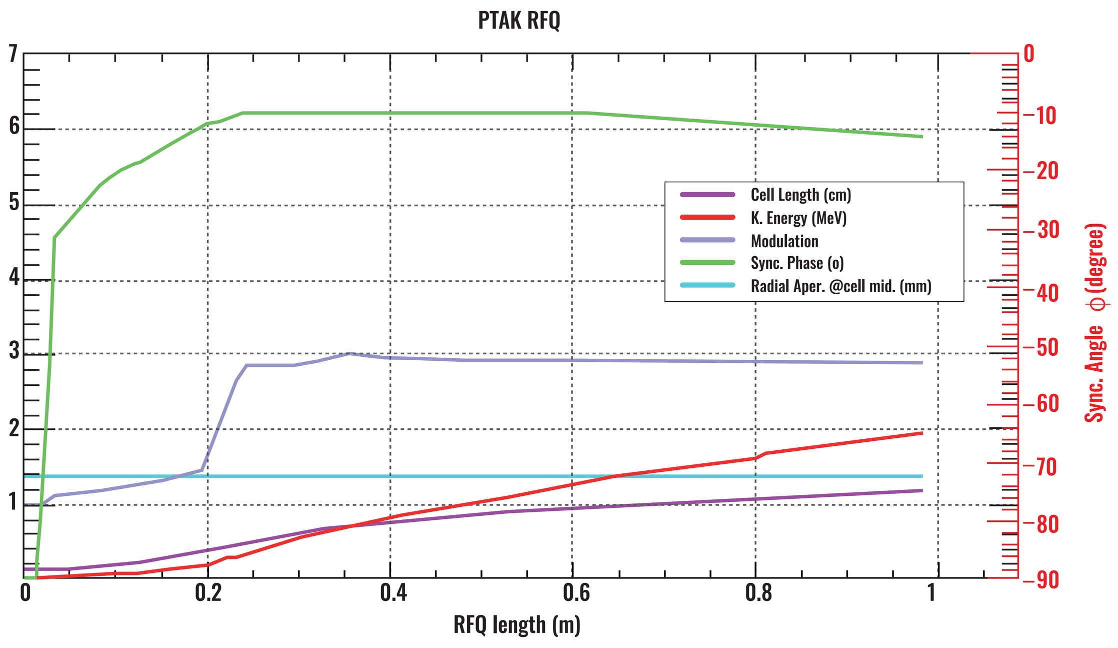
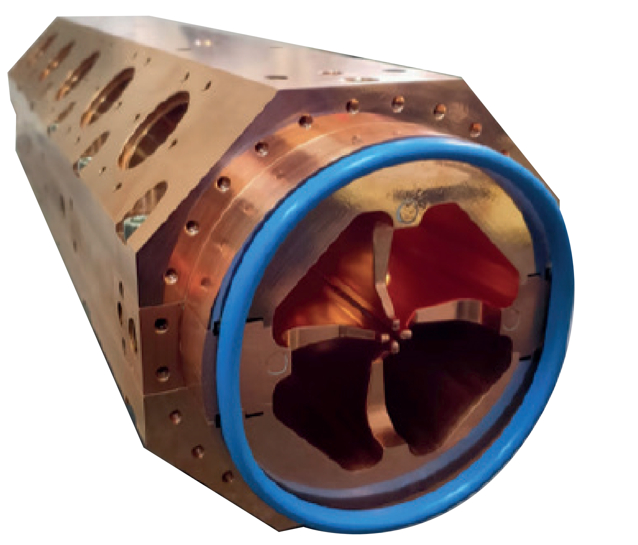
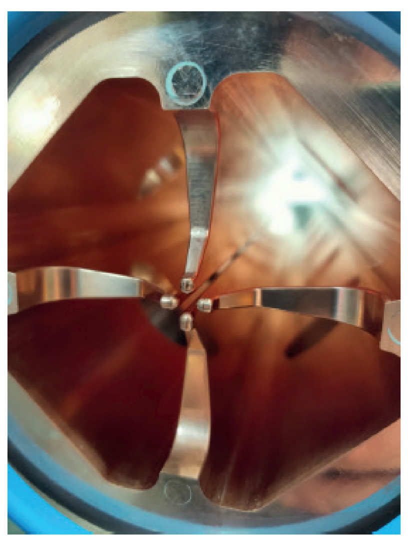
GENERAL DESIGN



PARAMETERS	PTAK - RFQ
RF FREQUENCY	800 MHz
LENGTH	980 mm
INPUT ENERGY	20 keV
OUTPUT ENERGY	2 MeV
VANE VOLTAGE	33 kV
MIN. APERTURE	0.64 mm
MAX. APERTURE	3.0 mm
VANE TIP RADIUS ρ	1.4 mm
TRANSMISSION	%30
ACCEPTANCE (total norm.)	0.16 π mm.mrad
RF PEAK POWER	48.5 kW
KP VALUE	1.39

PROTOTYPE PRODUCTION





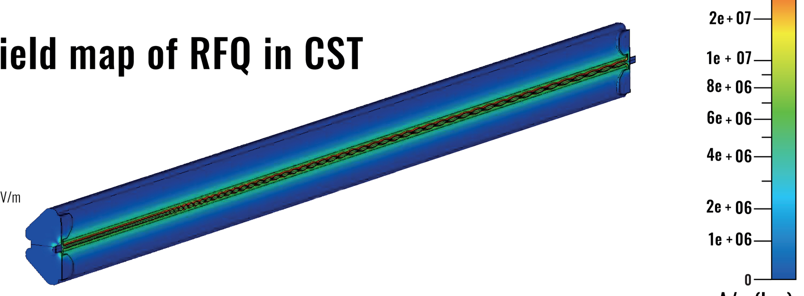
PARAMETERS	VALUE
Q_L	4162
Q_0	5850
S21	-41 dB
T	23 ℃
f	799.58 MHz
Mounting sensitivity	18 ± 1 um

ELECTROMAGNETIC DESIGN

Electric field and magnetic field simulations of RFQ are done by CST, 3D electromagnetic field simulation software, before the production process. According to simulations, in the case of all tuners are flush; frequency of quadrupole is 796.05 MHz, quality factor is 6973 and without tuners and RF ports.

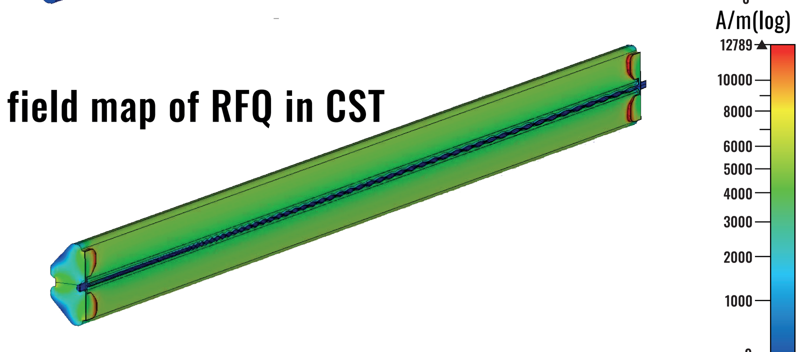
E

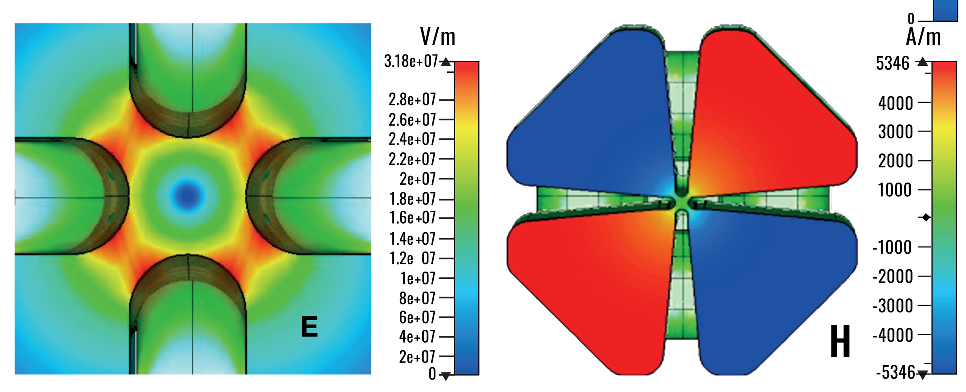
Electric field map of RFQ in CST



H

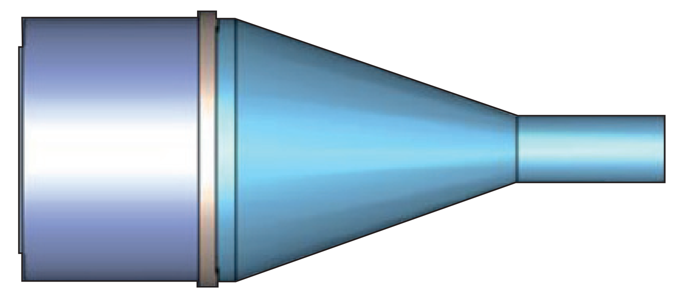
Magnetic field map of RFQ in CST

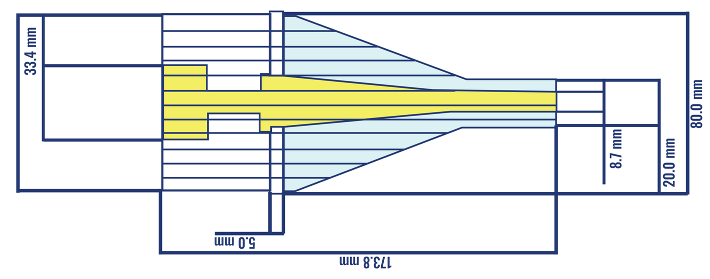




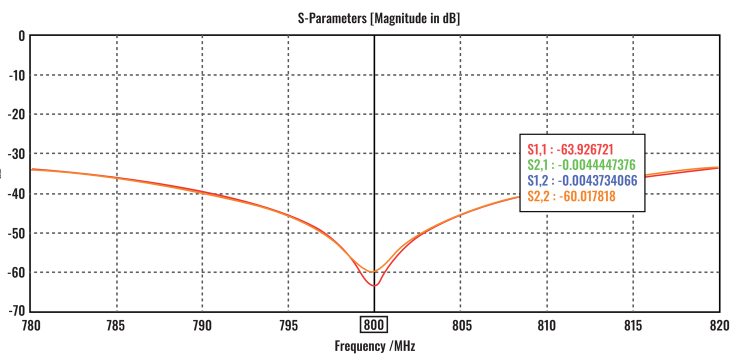
RF POWER COUPLER DESIGN

A coaxial power coupler is designed using alumina material as the RF window in the coupler design. Maximum power transmission and minimum power loss at 800 MHz were obtained for coupler designed according to the simulated S-parameter results.





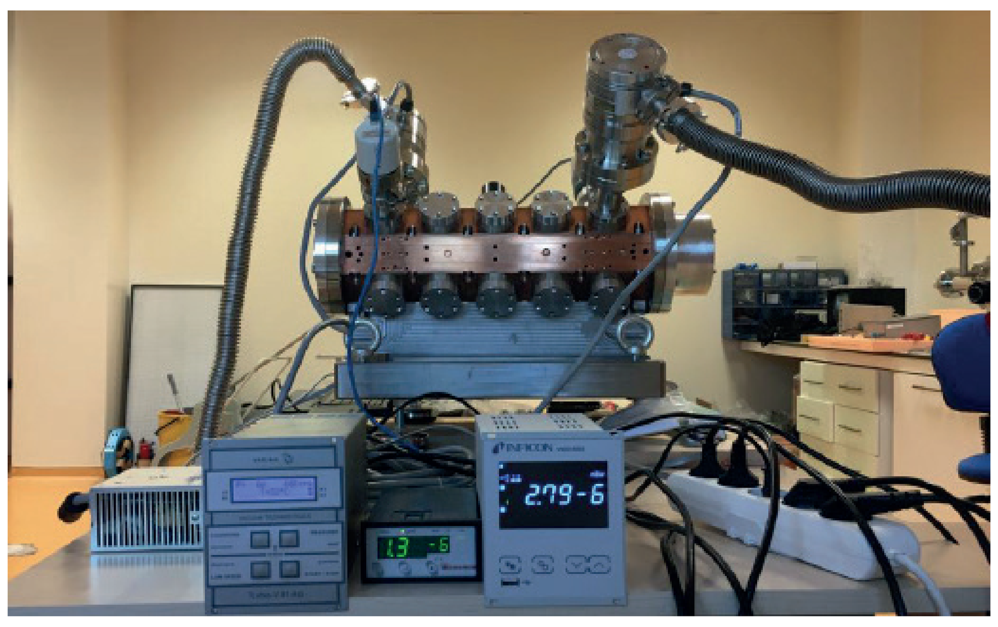
Alumina window coupler design and size image



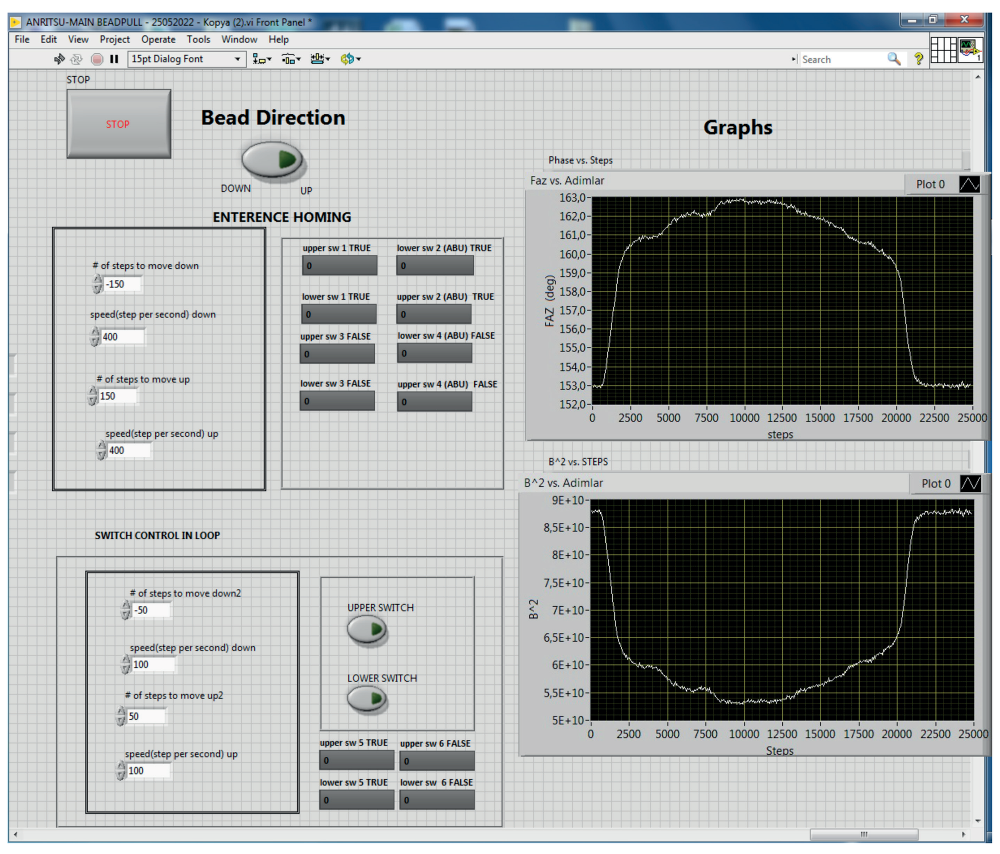
Simulated obtained S-Parameter Heights for alumina window coupler.

VACUUM TESTS

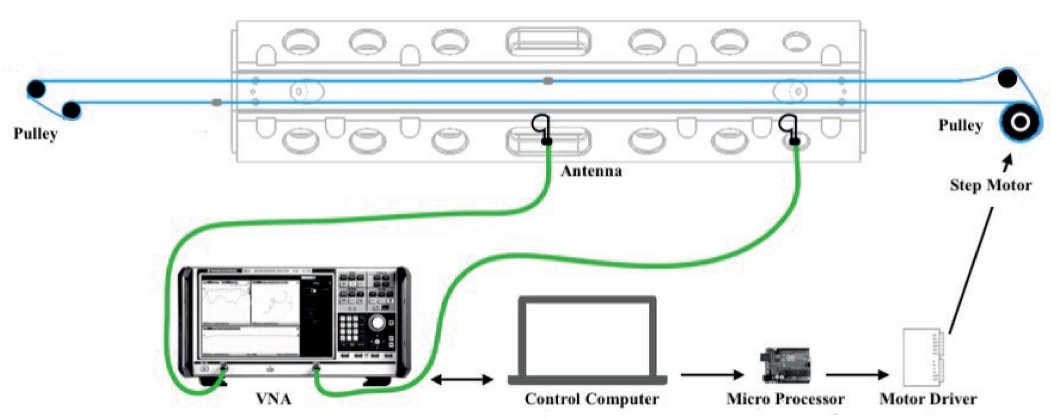
Vacuum test are finalized for RFQ prototype in Ankara, lowest value reached by turbo molecular pump is 2.79 x 10^{-6} mbar.



LABVIEW CONTROL PROGRAM



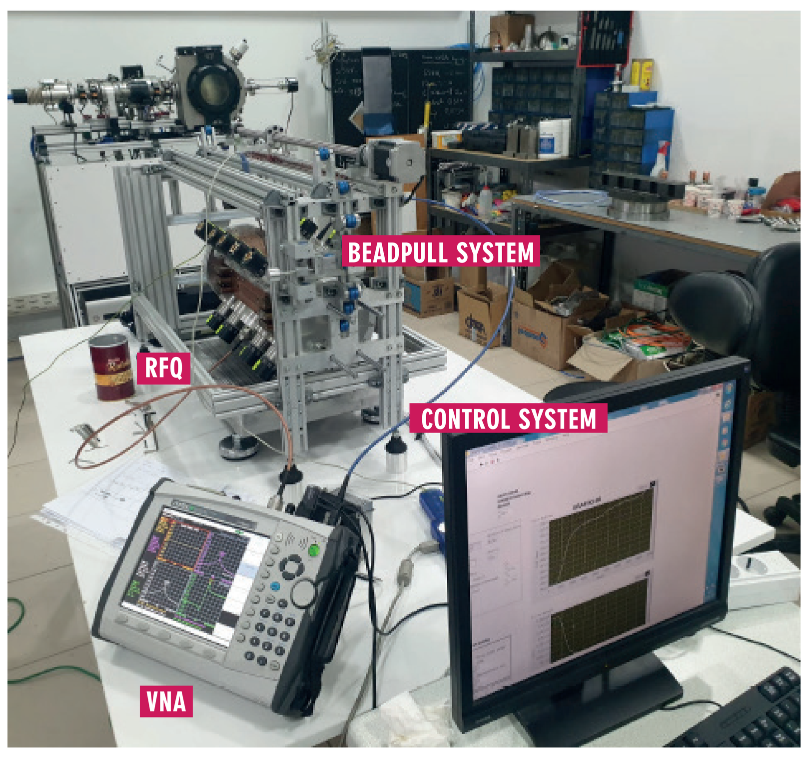
BEADPULL MEASUREMENTS



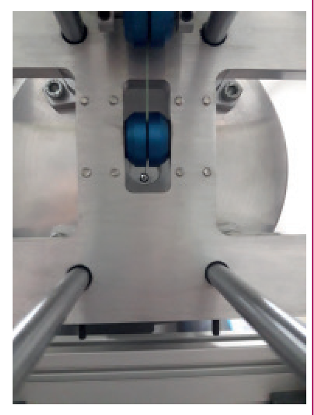
The smoothness of the electromagnetic field formed in the cavity is tested with a conductive or dielectric bead, which is selected according to the area in which the change is desired to be observed. Slater perturbation theory is used during the tests:

$$\frac{\Delta f}{f} \cong \frac{\Delta U}{U} = \frac{\tan[\phi(f)]}{2Q_L} = \frac{-\pi r^3}{U}\left(\epsilon_0\,\frac{\epsilon_r - 1}{\epsilon_r + 2}\,E_0^2 + \mu_0\,\frac{\mu_r - 1}{\mu_r + 2}\,H_0^2\right)$$

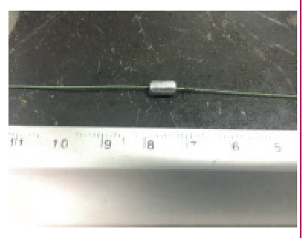
Experimental Setup

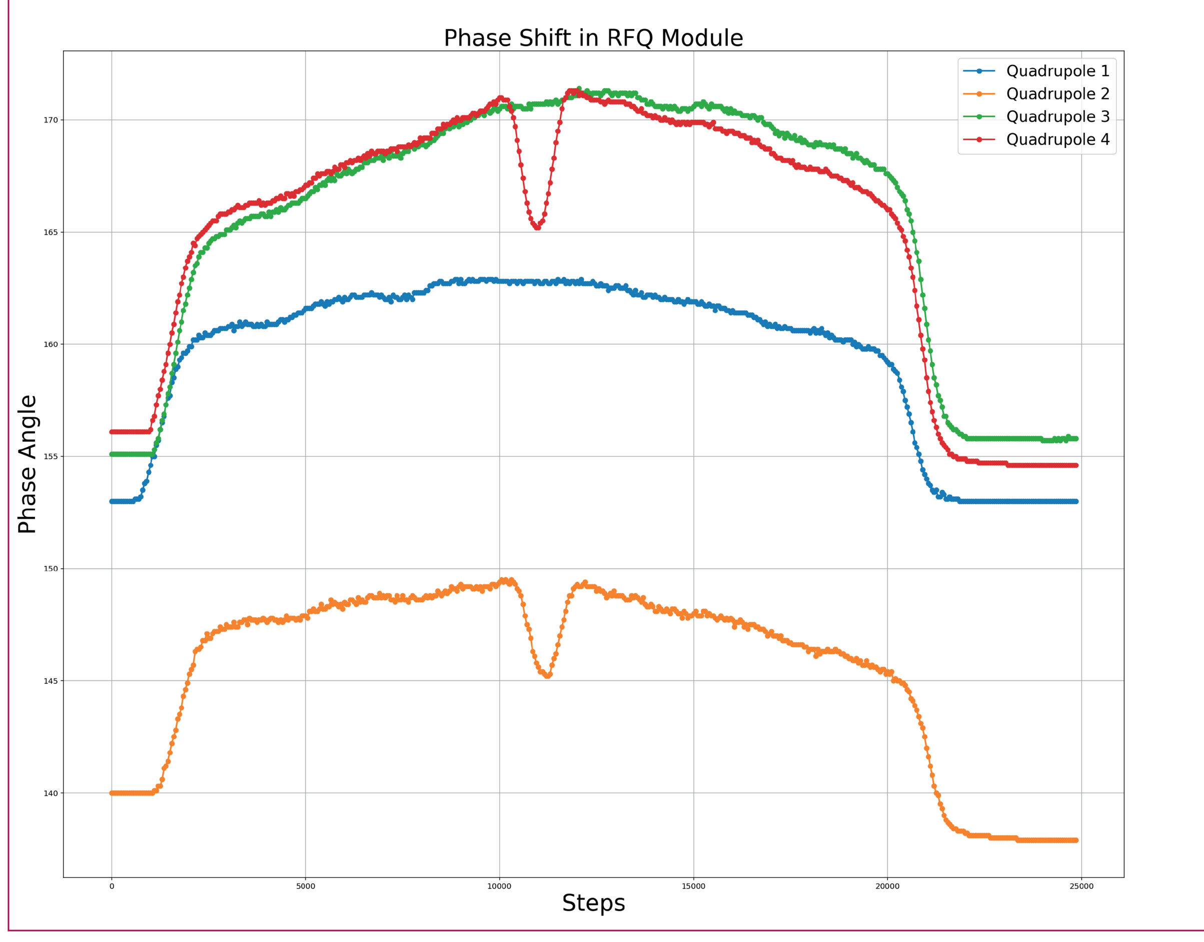


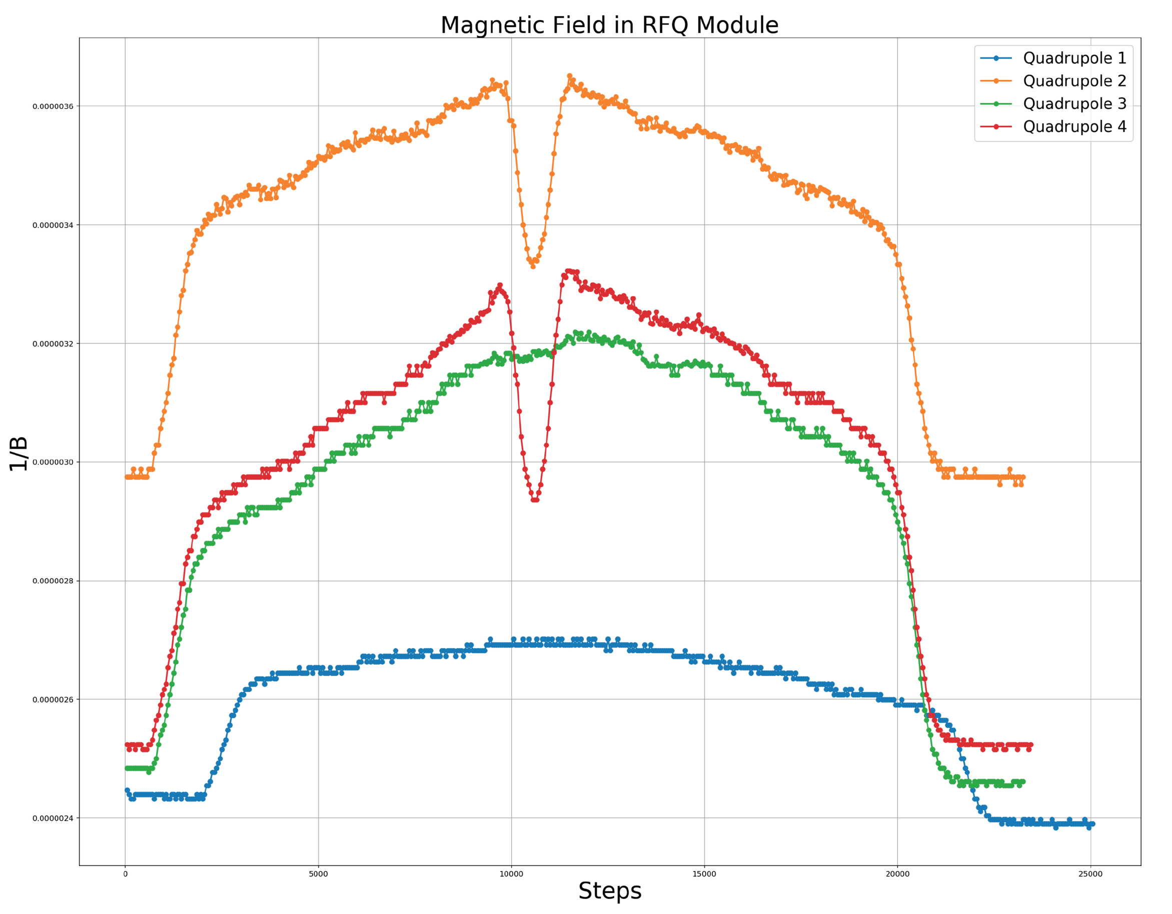
Centering Bead



Aluminium Bead

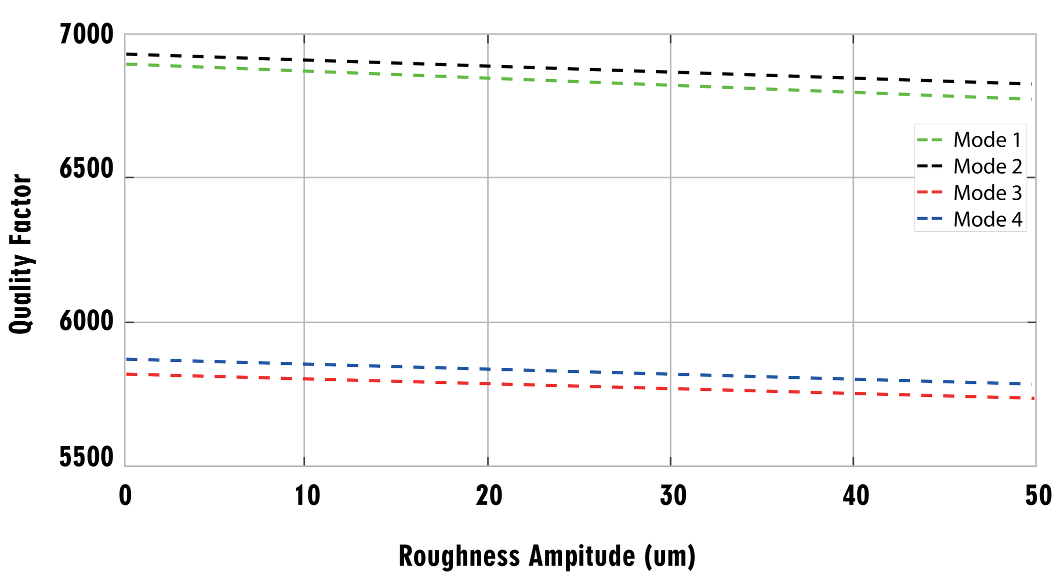


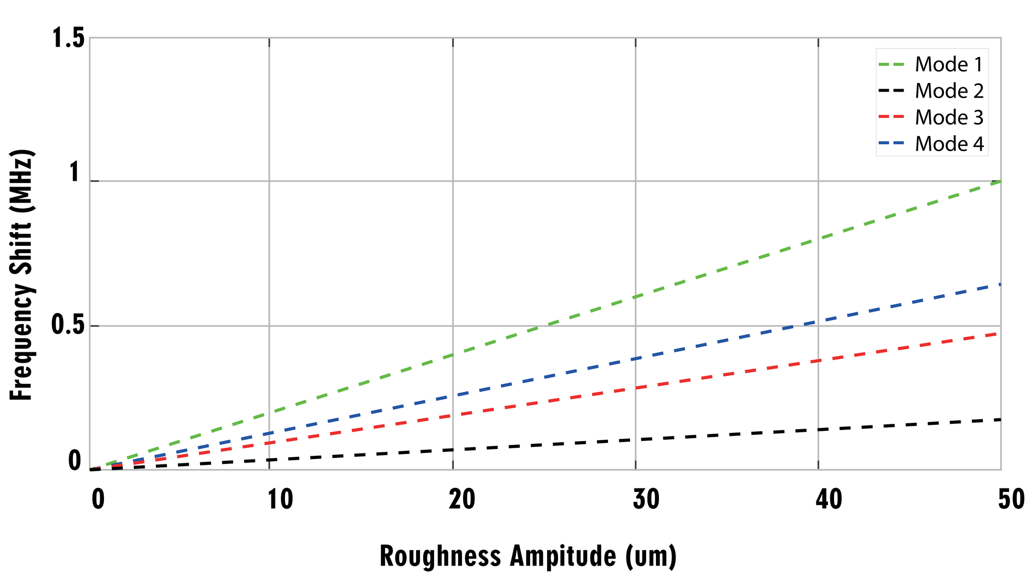




SURFACE ROUGHNESS

The amplitudes of the actual roughness added to the walls of the cavity were increased up to 50 micrometers. As a result of this roughness, the decrease in the quality factor of the fundamental modes of the cavity and the change in the resonant frequency were investigated. Even at an exaggerated level of 50 micrometers, the variation in quality factor and resonant frequency remained within tolerable limits.





CONCLUSIONS

Prototype RFQ module @ 800 MHz produced; mechanical, electromagnetic and vacuum measurements ongoing, electromagnetic field and related phase/frequency shift measurements made by bead-pull method, surface roughness simulations and related Q value changes are shared in the poster. Obtained Results and Future Goals:

•Surface roughness and mounting are playing important role to reach high conductivity and high quality factor Q.

•Experimental area temperature is critical for EM measurements.

•Changing phase and frequency affects the EM field inside the cavity, and it is important to provide desired electromagnetic field flatness to accelerate particles properly.

•The project aims to combine the 2 modules to accelerate the proton beam to 2 MeV energy by the end of 2023.

References;
[1] Bitter, R., Mohiuddin, T. ve Nawrocki, M., 2006.LabVIEW: Advanced programming techniques, version 2019, Crc Press., [2] Celebi, E., et al.,"Design and Construction of a Testbeam at KAHVELab", In preparation, 2022., [3] Esen, S.,"Space Charge Calculation and Electromagnetic Field Measurements for Low Beta Proton Accelerator", M.Sc. Thesis, 2021. [4] Kilicgedik, A., et al., "Rf measurements and tuning of the test module of 800 MHz radio-frequency quadrupole", LINAC2022, [5] Halis, D., et al.,"Emittance Measurements From The Testbeam At KAHVELab", LINAC2022.