LINAC2018 Beijing 16-21 September 2018

Tuning of a Four-Vane RFQ for Xi'an 200 MeV Proton Application Facility

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ABSTRACT

The procedures and results of tuning a four-vane Radio Frequency Quadrupole (RFQ) accelerator for the Xi'an 200 MeV Proton Application Facility (XiPAF) project is described. After tuning, the relative error of the operating quadrupole mode field is within ±2.7%, and the dipole mode component is within ±1.9% of the quadrupole mode.

INTRODUCTION

The Xi'an 200 MeV Proton Application Facility (XiPAF) project is a facility capable of providing single-event effect tests of semiconductor devices in spacecraft electronic systems. The accelerator part of the facility is mainly composed of one 7 MeV H- linac injector and one 200 MeV synchrotron. The RFQ is an important part of XiPAF linac injector.

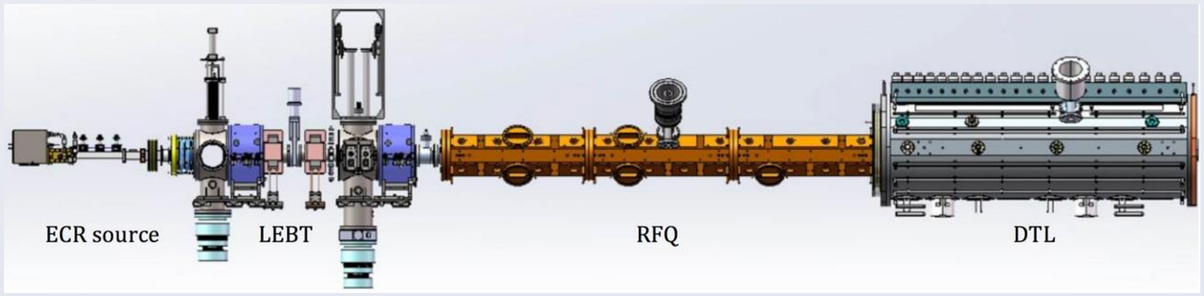

Figure 1 XiPAF linac injector

XIPAF RFQ DESCRIPTION

XiPAF RFQ will accelerate a 50 keV H- beam to 3 MeV, with a peak current of 5 mA. This RFQ is 3 meters long and consists of three segments. This RFQ is fed by only one coaxial power coupler. A total of 48 tuners are equipped in the four quadrants of the cavity. Four dipole-mode stabilizer rods are mounted on each of the two flanges. Undercuts are separately designed for each end of the RFQ.

Figure 2 Assembled XiPAF RFQ

Table1 Main design parameters of XiPAF RFQ

Parameters	Value	Unit
Particle	H-	
Input energy	50	keV
Output energy	3	MeV
Frequency	325	MHz
Peak current intensity	5	mA
Maximum reputation rate	0.5	Hz
Beam pulse length	10-40	Ms
Peak wall power	388	kW
Q0	8600	

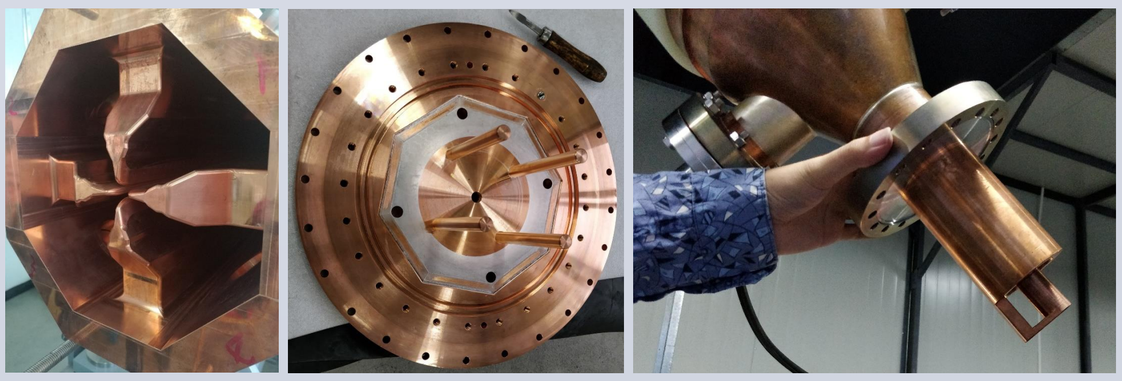

Figure 3 Undercuts, dipole-mode stabilizer rods, and coupling loop of XiPAF RFQ

EXPERIMENTAL SETUP

The magnetic field distribution near the outer wall is obtained by the bead-pull method. Field distribution is obtained by measuring the phase change of the S12 signal.

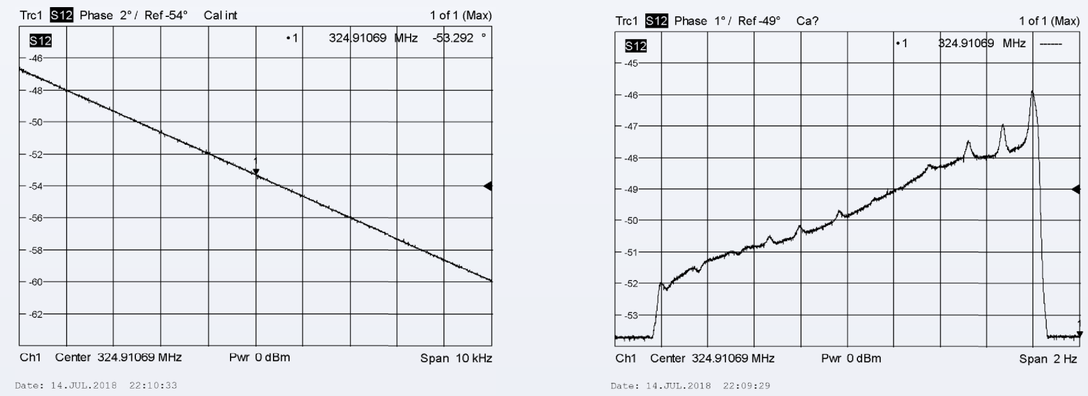

Figure 4 Assessment of the linear relationship between the S12 phase and frequency (left) and phase shift of signal S12 with the bead position (right) in one measurement.

PRE-BRAZE TUNING

Pre-braze tuning results:

1) Relative error of the operating quadrupole mode field is tuned from ±25.0% to ±2.0% but the dipole component is still large.
2) Frequencies of the nearest dipole mode are separated from the operating mode by 5.25 MHz.

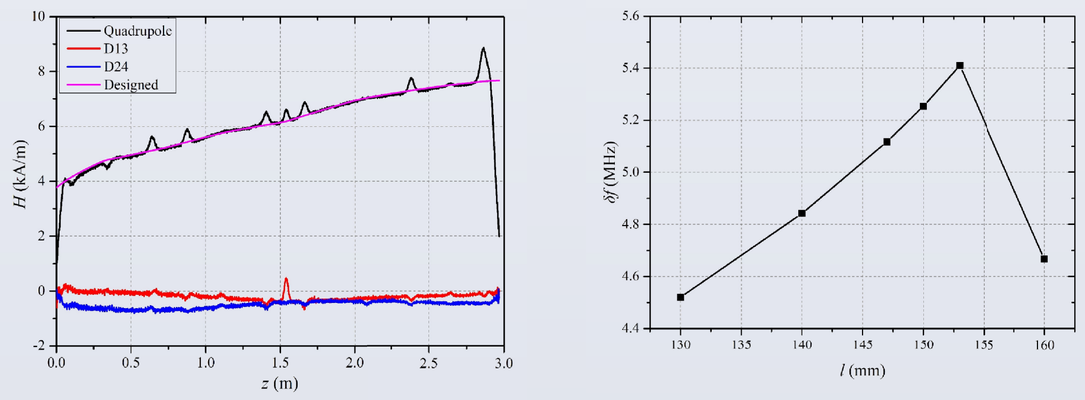

Figure 5 Field distribution after pre-braze tuning (left) and measured frequency between the operating mode and nearest dipole modes with the rod length (right)

FINAL TUNING

Final tuning results:

1) The relative error of the operating quadrupole mode field is within ±2.7%, and the dipole mode component is within ±1.9% of the quadrupole mode.
2) The difference between the frequency measured and target value is only 10 kHz.
3) The measured Q0 is 7300 but the designed value is 8600.
4) The measured coupling coefficient is 1.03 and the desired value is 1.04.

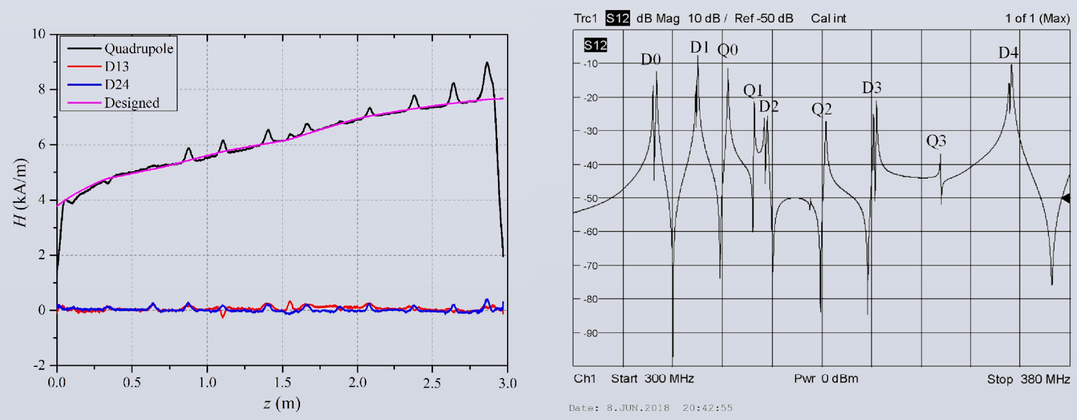

Figure 5 Field distribution (left) and frequency spectrum (right) after final tuning

CONCLUSION

The machining, assembly, and RF tuning of XiPAF RFQ cavity has been completed successfully. The relative error of the operating quadrupole mode field is within ±2.7%, and the dipole mode component is within ±1.9% of the quadrupole mode. The final measured coupling coefficient of the RF power coupler equals 1.03, with the desired value of 1.04.