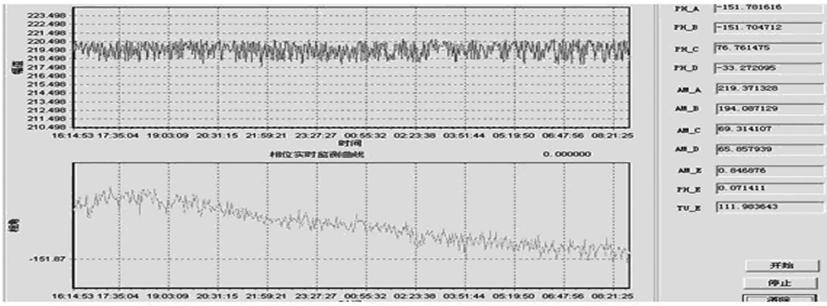

Fig. 2 LLRF twelve-hour amplitude stability and phase stability test result.

This LLRF control system is first generation based on completely digital IQ technology. The twelve-hour test results show(in Fig. 2) that the amplitude stability is 0.32%(peak to peak), ±0.18%(RMS), and the phase stability is ±0.35°(peak to peak), ±0.09°(RMS). In future, there will be much work to do, such as developing RF front end based on ICs, improving the reliability of LLRF, acquiring and debugging loop PI parameters in 4 K environment, optimizing algorithms, and so on. Although this LLRF is not so perfect, it performs well in room temperature in twelve-hour test.

6 - 10 RFQ Design of ADS Project at IMP

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China has launched its ADS (Accelerator Driven System) project since 2011 to deal with nuclear wastes and energy shortage problem. A high energy linear accelerator (LINAC) is necessary for the ADS. There are two front ends for the China's ADS LINAC, one of which will be built by IMP (Institute of Modern Physics). As one part of the front end, a four-vane RFQ has been designed in collaboration with LBNL (Lawrence Berkeley National Laboratory).

Table 1 Main parameters of ADS RFQ at IMP

Ion species	Proton
Frequency (MHz)	162.5
Input /Output energy (MeV)	0.035/2.1
Current (mA)	15
Input Emittance (nrms) (πmm · mrad)	0.3
Output trans. emittance (nrms) (πmm · mrad)	0.31
Output long. emittance (keV ns)	0.92
$\alpha_{in}/\alpha_{xout}$, α_{xout}	1.21/0.36, −0.3
Inter-vane voltage (kV)	65
K_p factor	1.2
Minimum aperture (mm)	3.2
Modulation	1～2.38
Synchronous phase (deg)	−90～−22.7
Cavity length (cm)	420.8
Transmission efficiency (%)	99.6

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The RFQ is designed to accelerateproton beam from 35 keV to 2.1 MeV above which small neutron production and material activation will happen, and main parameters are listed in Table 1. The frequency of 162.5 MHz is chosen in order to decrease the power loss density of the cavity. The inter-vane voltage is 65 kV, which leads to a small kilpatric factor of 1.2 and can well reduce the probability of discharge. The twiss parameters and emittances of output beam are required to be less than 1.5, 0.33 πmm · mrad and 1 keV ns respectively, Table 1 shows all these requirements are met. Because the cavity is 420.8 cm long, it will be equally divided into four modules when fabrication.

The geometry of the RFQ cavity is shown in Fig. 1, which shows four-vane structure has been adopted. Pi-mode rods are utilized to increase the space between the operation frequency and adjacent dipole frequency. The average aperture γ_0 of the RFQ is 5.731 mm, and the ratio of vane-tip radius ρ to γ_0 is 0.75.

RF design has been done by the CST Microwave Studio code step by step, the sequence is thin cross section calculation, Pi-mode rods calculation, tuner calculation, cutback calculation and complete model calculation. One can see thatfrom Fig. 1, the full model has 16 pairs of pi-mode rods and 80 tuners. Parameters of the cavity are shown in Table 2.

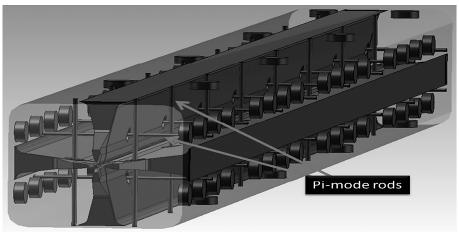

Fig. 1 Complete model of the ADS RFQ at IMP.

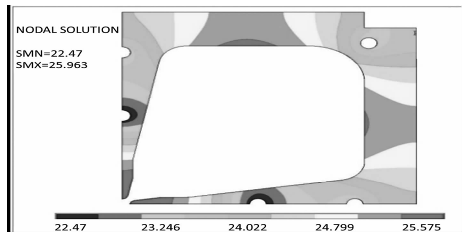

Fig. 2 Temperature contour of the ADS RFQ at IMP.

Table 2 Parameters of the RFQ cavity

Radius (mm)	Freq. (MHz)	Dipole freq. (MHz)	Q factor	Total power (kW)
173.03	162.513	183.6	14934	83.5

Thermal analysis was done with the ANSYS code to study the cavity cooling issues and to know about how to tune the cavity by adjustment of cooling water temperature. Layout of cooling channels is displayed in Fig. 2, there are total eight cooling channels (diameter is 12 mm) in the wall and four in vanes for each module. Temperature of the injecting cooling water was assumed 20 ℃, and velocity of the cooling water was 2.29 m per second. Basing on the data mentioned above, temperature distribution of the cavity is shown in Fig. 2, and the relationship between cavity shifting frequency and cooling water temperature is -16.125 kHz/℃ for vane and 12.875 kHz/℃ for wall respectively.

6 - 11 IMP Superconducting HWR Design, Fabrication and Cold Test

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Zhang Shengxue, Xu Mengxin, Guo Hao, Lu li, He Shoubo, Zhang Cong, Wang Ruoxu
Huang Shichun, Wang Fengfeng, Huang Yulu, Yang Yuzhang, Li Chunlong
Xue Zongheng, Zhang Rui, Zheng Hai, Shi Zhixiong, Wang Wenbin
Song Yukun, Su Hailin, Su Li, Zhu Zhenglong and Zhao Hongwei

The R & D program of IMP superconducting HWR is based on the China ADS. The aim is to build and test a HWR prototype on December 2012. We have designed, fabricated and vertical tested a 162.5 MHz β=0.09 half-wave resonator (HWR) this year. The cavity can be operated at 4.2 K with $E_{acc}>4.9$ MV/m. Performance exceeds C-ADS specifications of an input power of 10 W at 4.2 K and $E_{acc}=4.7$ MV/m.