Advances in the Construction of the IH-RFQ at MAFF

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The low energy part of the LINAC of the MAFF facility will be an IH-RFQ cavity with 101.28 MHz resonance frequency. The RFQ is designed to deliver ions of A/q = 6.3 up to 300 keV/u to be injected into the following LINAC. The structure chosen was an IH type of resonator since it was demonstrated to have a better shunt impedance [1]. The required maximum voltage between the electrodes is 70 kV and the operation mode is pulsed with a duty cycle of 10%. The structure is made out from bulk copper in order to improve the shunt impedance and hence to allow indirect cooling on the electrodes.

The driver for the production of exotic isotopes of the Munich Accelerator for Fission Fragments (MAFF) [2], the research reactor FRM-II in Garching (Germany), has been commissioned successfully. The first acceleration stage for the radioactive ions has been funded. The first part of the acceleration chain consists in an IH-type of Radio Frequency Quadrupole (RFQ) at 101.28 MHz, running at 10 % of duty cycle. As the maximum intensity of exotic beams from the MAFF target ion source is about $10^{10} - 10^{12}$ ion/sec a high transmission and low emittance growth are required. Therefore the rod voltage and thus the focusing strength have been raised, which influence the RF layout. Details about the optics and the beam dynamics choices of the accelerator can be found in [3]. The overall length of the resonator is 2894 mm with the electrode length equal to 2810 mm. The equivalent effective voltage gain is 1.871 MV with a peak power dissipation of 78 kW. The maximum duty cycle is 10% so the average power dissipation is 2.6 kW/m which can be cooled easily. The structure is modular in order to facilitate the construction: there are five identical central-modules whose length is 400 mm and two end-modules whose length is 425 mm. The modular concept does not spoil the RF properties of the resonator since the longitudinal surface currents are negligible.

As mentioned above the concept for the mechanical construction of the full power resonator foresees five identical central modules 400 mm long and two identical end modules 425 mm long which will be made out from bulk copper. Fig. 1 shows a 3D section of a central module.

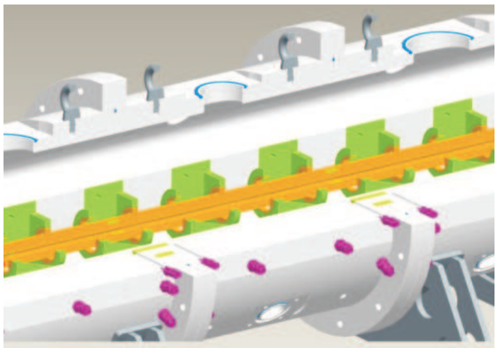

Fig. 1: 3D image of one of the central modules.

This concept is based on the fact that there is virtually no longitudinal current so any transverse cut does not interfere with the RF behavior of the cavity. The advantage of having such a concept is that the manufacturing of small pieces can be done with very high accuracy, so to meet the tolerances required from beam dynamics. In fact since the alignment of the electrodes will be done on an external frame, it is mandatory to have the stems and the ridges where they are mounted as accurate as possible, so that the alignment can be preserved. The tolerances on the construction are tight: the error on the two planar surfaces of the ridges has to be within 50 μm. After mounting the stems apertures are machined with an accuracy of 50 μm. The correct connection between modules will be guaranteed by the use of pins which will be used as reference points, which define the axis. Each module has four ports which are used as ports for the vacuum pumps, vacuum gauges, coupler and pick-up. The sealing will be done using Viton O rings. The vacuum requirements for highly charged ions demands for 10^{-8} mbar: only at this level in the first part of the RFQ the beam loss due the charge exchange is negligible. Specifications about the vacuum system can be found in [4]. As for the cooling system, each stem has an independent cooling circuit, while the ridge is cooled by means of three independent channels running close to the flat ridge surface and to the conjunction with the main cylinder. The cooling channels on the stems have been designed to be very close to the electrodes connections, since the highest current density is located there. For the isolation between water and vacuum small Viton O-rings will be used. The cylinder itself will be cooled externally with channels attached to each quadrant. The modules are now being produced, see Fig. 2 and the delivery will be in spring 2005.

Fig. 2: The picture shows one of the central modules after the machining procedure.

References

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[3] M. Pasini *et al.*, EPAC 2004, conference proceedings, p.1219
[4] M. Pasini, “Specification for the Vaccum System of the MAFF-IHRFQ“, Design Note.