Technical Design of an RFQ Injector for the IsoDAR Cyclotron

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INTRODUCTION

Within the framework of the IsoDAR and DAEALUS "Sterile Neutrino experiments" intense proton driver beams are requested. The first stage is a 60 MeV/amu cyclotron delivering 5 mA of H\(^{3+}\) ions, which is equivalent to a 10 mA proton beam.

To alleviate the requirement of very high primary beam currents from the ion source and reduce the massive particle losses in the central region, a novel type of injection, using an RFQ, accelerating protons from 7.5 keV/amu to 35keV inserted into the cyclotron yoke to pre-bunch the beam with high efficiency, was proposed by the MIT group (which leads the accelerator design for IsoDAR). This concept had been proposed before in 1981 by RW Hamm, but was never realized.

BEVATECH GmbH is collaborating with MIT to develop the technical design of this cw operated RFQ running at 32.8 MHz matching the cyclotron frequency.

MECHANICAL DESIGN

The main challenges in the mechanical RFQ design are:

1. Alignment and stabilization of the quadrupole electrodes positions (±0.1mm)
2. Suppression of mechanical electrode vibrations (shifting the electrodes' mechanical vibration resonances above 100Hz)
3. Using metals which allow closed circuit water-cooling at around 0.6 MPa and integration in the typical circuits as used for copper/stainless steel structures.
4. Small outer cavity diameter along the high energy end (below 300mm)
5. Mechanically well-designed RF tuning options to reach and control the frequency

The vane stabilizers help to keep the distances between two vanes but cannot fix the vane ends against the cavity walls. Two types of mechanical vibrations are distinguished:

1. Vibrations between vanes on different RF potential, where Lorentz force detuning can happen
2. Vibrations with only weak coupling to the RF oscillation

Pair of vanes of the split coaxial RFQ

Mechanical quarter wave oscillation modes of the vane pairs at 18Hz and 25Hz.

Pair of electrodes with stabilizers and opening in the other electrode pair for the bridging

RF DESIGN

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Frequency</td>
<td>32.9 MHz</td>
</tr>
<tr>
<td>Tuning Range*</td>
<td>±270 kHz</td>
</tr>
<tr>
<td>Power losses</td>
<td>4.2 kW</td>
</tr>
<tr>
<td>Q simulated</td>
<td>2.800</td>
</tr>
<tr>
<td>Shunt impedance R_s</td>
<td>4.9 kOhm/m</td>
</tr>
<tr>
<td>Total RF power</td>
<td>5.33 kW</td>
</tr>
</tbody>
</table>

CST MWS Design Parameters

Simulated frequency (left) as function of the electrode width without frequency correction for 32 MHz and tuning range of the plungers (right)