Technical Design of an RFQ Injector for the IsoDAR Cyclotron

IPAC 2021

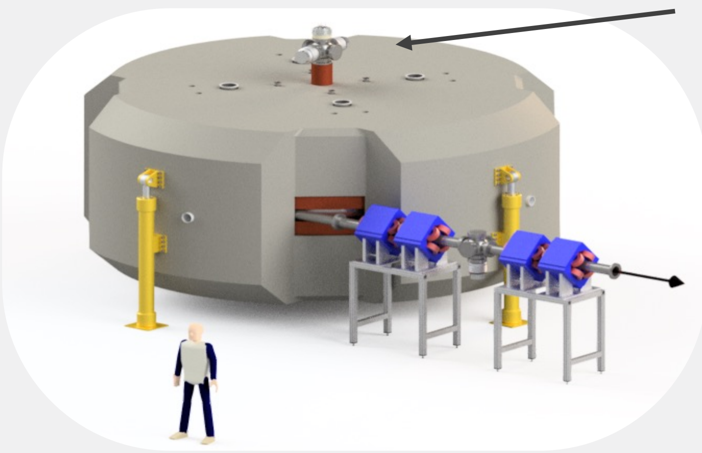
H. Hoeltermann†, U. Ratzinger, H. Podlech, M. Schuett[1], M. Syha[1], B. Koubek,
BEVATECH GmbH, Frankfurt, Germany
D. Winklehner, J. M. Conrad, D. Koser, L. H. Waites, J. Smolsky,
Massachusetts Institute of Technology, Boston, United States of America
[1]Institute of Applied Physics, Johann Wolfgang Goethe-University, Frankfurt, Germany

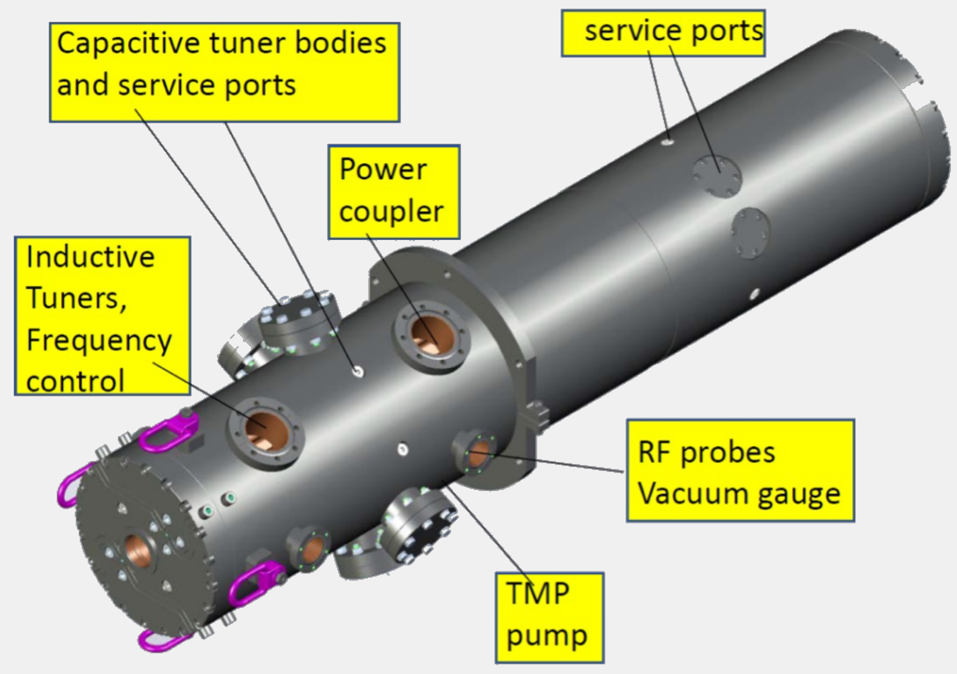
INTRODUCTION

Within the framework of the IsoDAR and DAEδALUS "Sterile Neutrino experiments" intense proton driver beams are requested. The first stage is a 60 MeV/amu cyclotron delivering 5 mA of H_2^+- 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 35AkeV 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.

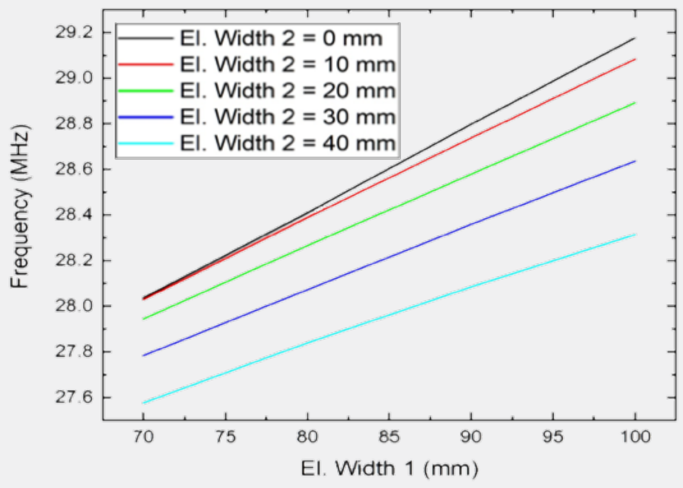


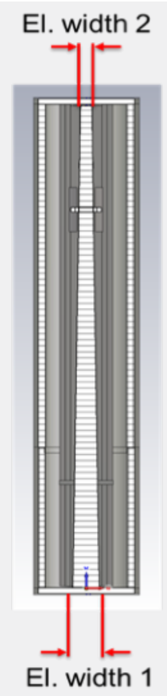


RF DESIGN

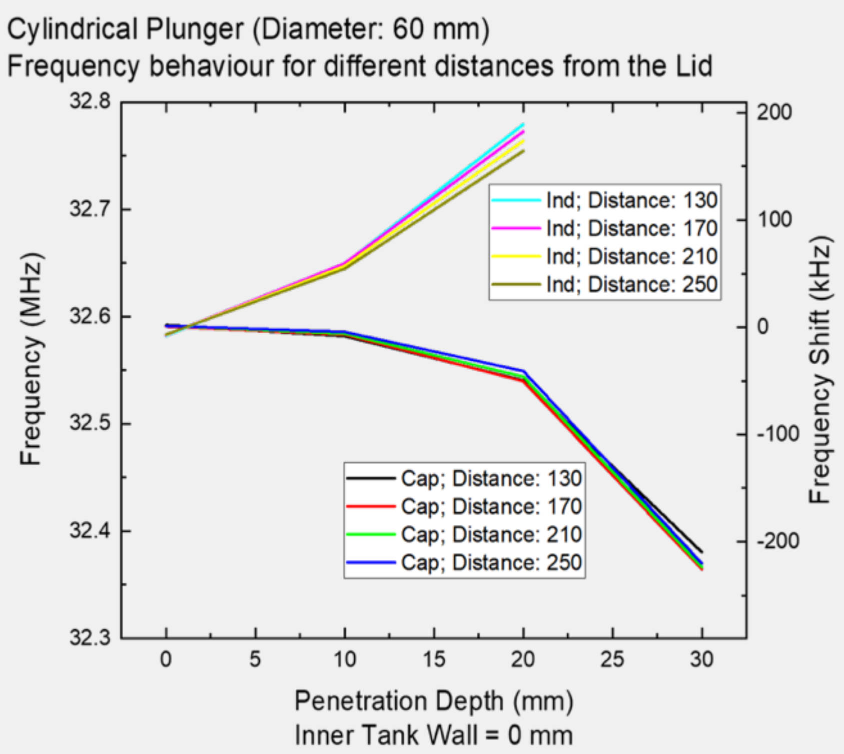
Parameter	Value
Frequency	32.9 MHz
Tuning Range*	±270 kHz
Power losses	4.2 kW
Q simulated	2.800
Shunt impedance R_p	4.9 kOhm/m
Total RF power	5.33 kW

CST MWS Design Parameters





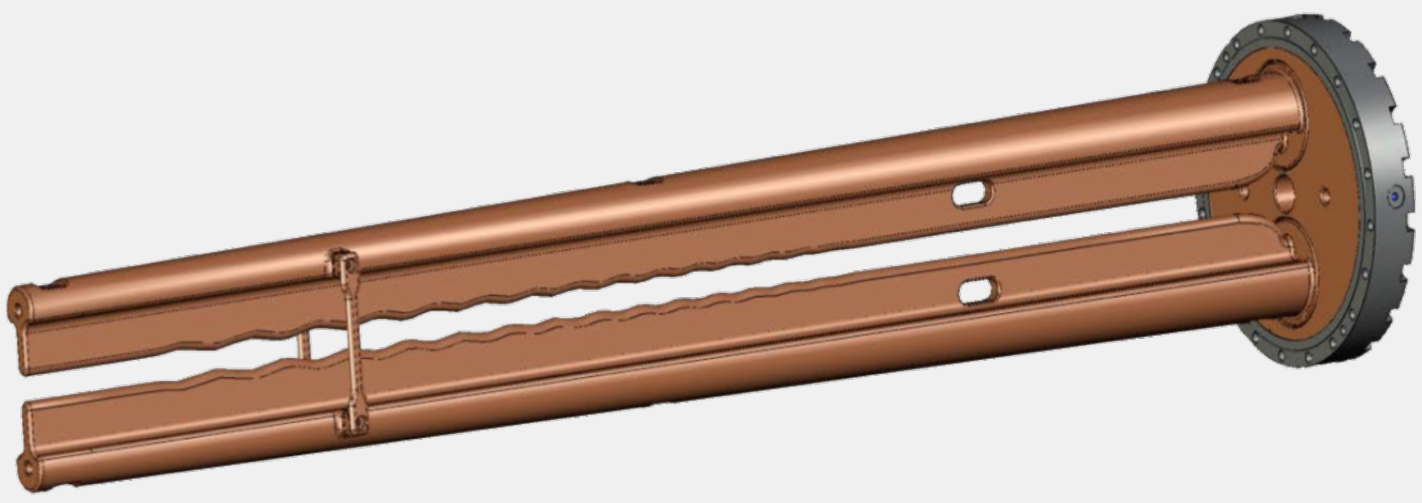
Simulated frequency (left)as function of the electrode width without frequency correction for 32 MHz and tuning range of the plungers (right)



MECHANICAL DESIGN

The main challenges in the mechanical RFQ design are:

1. Alignment and stabilization of the quadrupole electrodes positions ($\pm 0.1mm$)
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 $0.6MPa$ 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



Pair of vanes of the split coaxial RFQ

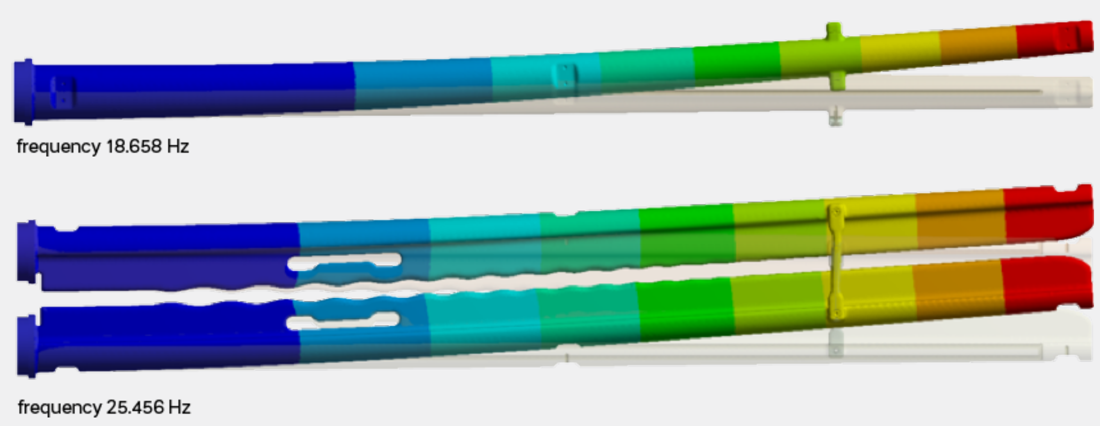
Pair of electrodes with stabilizers and opening in the other electrode pair for the bridging

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

1. Vibrations with only weak coupling to the RF oscillation

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



Massachusetts Institute of Technology

BEVATECH