General Layout of the 17 MeV Injector for MYRRHA *

H. Podlech #1, M. Amberg #1,2, H. Klein 1, D. Mäder 1, U. Ratzinger 1, A. Schempp 1, R. Tiede 1, M. Vossberg 1, C. Zhang 1

1IAP Frankfurt University, 60438 Frankfurt am Main, Germany
2Helmholtz-Institut Mainz (HIM), 55099 Mainz, Germany

Abstract:
The MYRRHA Project (Multi Purpose Hybrid Reactor for High Tech Applications) at Mol/Belgium will be a user facility with emphasis on research with neutron generated by a spallation source. One main aspect is the demonstration of nuclear waste technology using an accelerator driven system. A superconducting linac delivers a 4 mA, 600 MeV proton beam. The first accelerating section is covered by the 17 MeV injector. It consists of a proton source, an RFQ, two room temperature CH cavities and 4 superconducting CH-cavities. The initial design has used an RF frequency of 352 MHz. Recently the frequency of the injector has been set to 176 MHz. The main reason is the possible use of a 4-rods-RFQ with reduced power dissipation and energy, respectively. The status of the overall injector layout including cavity design is presented.

Layout of the 17 MeV Injector for MYRRHA

The injector will accelerate the beam to an energy of 17 MeV. The frequency has been changed from 352 MHz (EUTROTRANS) to 176 MHz. One main reason is the use of a 4-Rod-RFQ at the lower frequency. After the RFQ two room temperature CH cavities are used to cover the energy range between 1.5 and 3.5 MeV. The main acceleration is finally provided by 4 superconducting CH-cavities with superconducting solenoids in between.

Parameter | Unit | Value
--- | --- | ---
Energy | MeV | 17
RF frequency | MHz | 176
Particles | – | protons
Beam current | mA | 4
Operation mode | – | cw
RF structures | – | 4-Rod-RFQ/CH-DTL

1.5-3.5 MeV, 176 MHz Room Temperature CH-Section

Room temperature 176 MHz CH-cavities are foreseen to accelerate the beam from 1.5 to 3.5 MeV. To avoid an internal focusing element two cavities have been chosen. Each cavity provide about 1 MV of effective voltage. Both cavities have a β-profile for the length of the accelerating cells.

Parameter | Unit | Value
--- | --- | ---
RF structure | – | 4 CH-DTL
RF frequency | MHz | 176
Length (L) | cm | 54/65
H₀ | MV/m | 1.09/1.14
Z₀ | MV/m | 1.91/1.72
Q₀ (85% MW) | – | 15000
Z₀ (25% MW) | MW/m | 124/93
κ₀ | kW/m | 16/21
P/1 | kW/m | 30/52

1.5 MeV, 176 MHz 4-Rod RFQ

As RFQ-structure a 4-Rod-RFQ at 176 MHz has been chosen because of the lower technical risk, excellent tuning possibilities and easy access. The electrode voltage has been set to 40 kV to keep the thermal load on the RFQ as low as possible. An estimated impedance of 67 kΩ will result in a thermal load of less than 25 kW/m per metre which is considered to be a safe value for reliable operation.

Parameter | Unit | Value
--- | --- | ---
RF structure | – | 4-Rod RFQ
RF frequency | MHz | 176
Length | cm | 400
Elast. voltage | kV | 40
Impedance | kΩ | 67
Thermal load | kW/m | 25
RF power | kW | 100
E₀ | kV | 36
E₀ | kV/m | 1500

3.5-17 MeV, 176 MHz Superconducting CH-Section

The main acceleration of the injector is provided by 4 superconducting CH-cavities operated at 176 MHz. The cavities provide an effective voltage between 3.5 and 4 MV. The gradient has been set to a moderate value of around 4 MV/m to limit the electric peak fields below 25 MV/m for safe operation.

Parameter | Unit | Value
--- | --- | ---
RF structure | – | sc CH-DTL
RF frequency | MHz | 176
Length ($) | cm | 87/101/107/1.07
H₀ | MV | 3.002/3.005/3.008/3.00
Z₀ | MV/m | 4.02/3.94/3.89/3.82
R₀/Q₀ | Ω | 3000
Q₀ (design @Ea) | – | 2.10²
P₀ | kW | 20/30
G | kW/m | 50/60
Gaps | – | 16/30/30
Aperture Ø | mm | 30/30/40

*Work supported by European Union FP7-MAX Contract Number 269565.
**Theodor-Heuss-Allee 1, 60438 Frankfurt am Main, Germany
[Image: General Layout of the 17 MeV Injector for MYRRHA]