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STATUS AND DEVELOPMENT OF THE MYRRHA INJECTOR

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Abstract

The MYRRHA project aims at coupling a cw 600 MeV, 4 mA proton linac with a sub-critical reactor as the very first prototype nuclear reactor to be driven by a particle accelerator (ADS). Among several applications, MYRRHA main objective is to demonstrate the principle of partitioning and transmutation (P&T) as a viable solution to drastically reduce the radiotoxicity of long-life nuclear waste. For this purpose, the linac needs an unprecedented level of reliability in terms of allowable beam trips. The normal conducting injector delivers 16.6 MeV protons to the superconducting main linac. The first section of the injector (up to 5.9 MeV) consists of an ECR source, a 4-Rod-RFQ and a rebunching line followed by 7 individual CH-type cavities. This entire section will be set up and operated by SCK·CEN in Louvain-la-Neuve, Belgium, for ample performance and reliability testing. The first CH cavity has been sent for power tests to IAP Frankfurt, Germany. The most recent status of all cavities, couplers and the beam diagnostics of the MYRRHA injector is presented in this paper.

INTRODUCTION

The design of all components of the first section of the MYRRHA Injector (up to 5.9 MeV) has been completed. While most linac components are in the procurement phase, the first CH cavity has left the fabrication and is currently performing the high power tests at IAP. From the third cavity the CH structures are going to be power tested with the MYRRHA SSA [1].

INJECTOR SETUP

The 23 m long linac is installed inside the bunker at SCK·CEN in Louvain-la-Neuve. The control electronics and the power amplifier are placed on the top of the bunker. All cables, rigid lines and the cooling pipes run through 13 chicanes in the bunker roof.

RF CAVITIES

Two identical QWR Rebuncher cavities and 7 CH cavities (see Fig. 1) with a constant phase drift tube configuration are located behind the 4-Rod-RFQ in the first section of the MYRRHA Injector [2][3]. All cavities in this section have a design frequency of 176.1 MHz. The QWR structures are currently in fabrication scheduled to be finished October 2018. Each Rebuncher cavity has two gaps. The number of gaps increases in the following CH cavities up to 9 gaps in the seventh CH cavity (see yellow candles in Fig. 2).

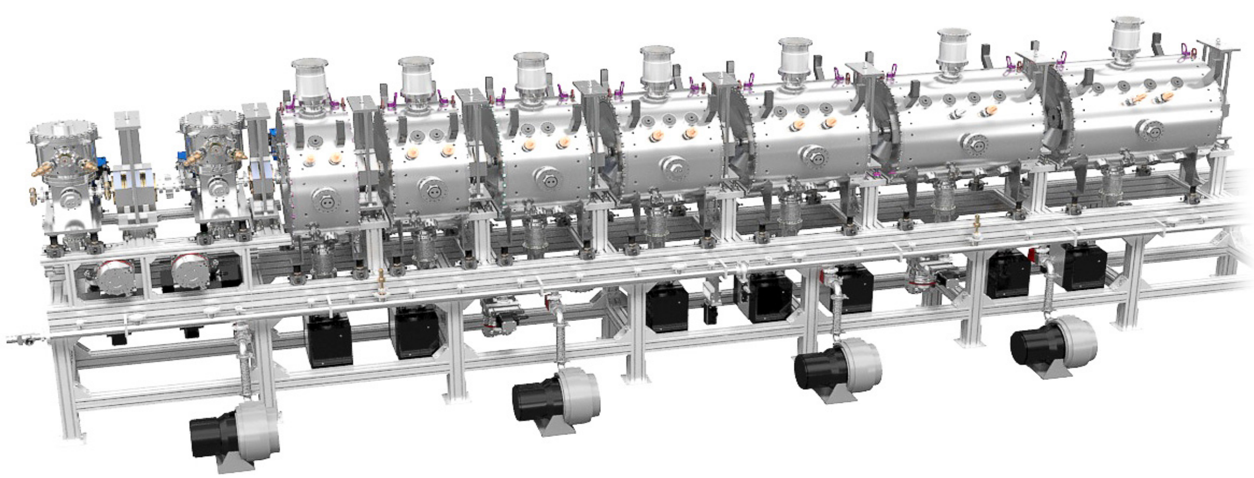

Figure 1: MEBT-1 and CH section of the MYRRHA Injector up to 5.9 MeV.

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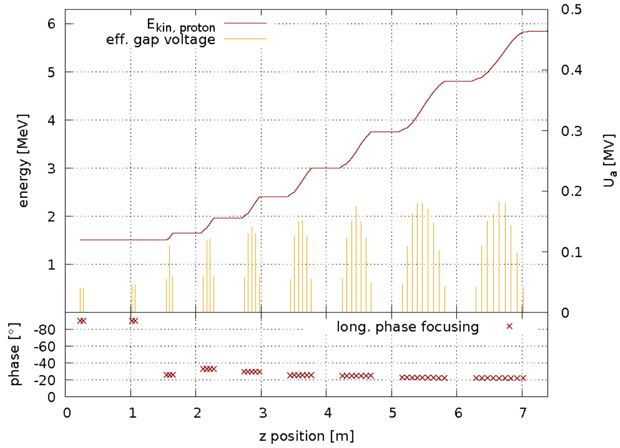

Figure 2: Beam dynamics of first injector section.

The CH Cavity 1 successfully performed the factory acceptance tests in January 2018 (see Table 1 and Fig. 3) and was copper plated with layer thickness of 50 µm and polished in April 2018 (see Fig. 4). Currently, CH cavity 1 is performing the high power rf tests at IAP Frankfurt and will be pre-conditioned before shipment to SCK·CEN in August 2018. Currently, CH cavity 2 is having its factory acceptance tests and is scheduled to be shipped for copper plating in May 2018.

Table 1: Simulated and Measured Parameters of CH Cavity 1

Parameter	Value
Sim. frequency with tuners	176.1 MHz
Sim. freq. without tuners	177.244 MHz
Meas. freq. without tuners (before copper plating)	177.251 MHz
Measured tuning range	2.1 MHz
Measured tuning sensitivity	23 kHz / mm
U_{G1}/U_{tot} (meas. / sim.)	22.8% / 25.9%
U_{G2}/U_{tot} (meas. / sim.)	51.7% / 48.0%
U_{G3}/U_{tot} (meas. / sim.)	25.5% / 26.1%

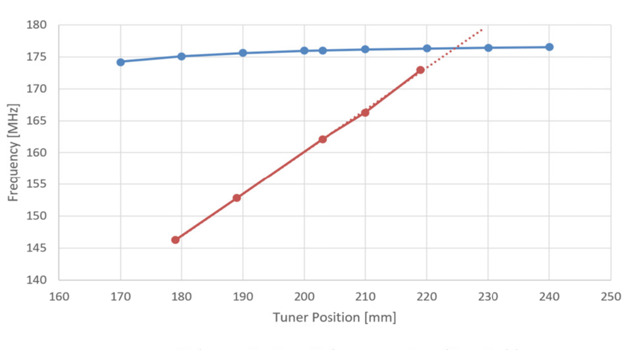

Figure 3: Measured tuner sweep of CH cavity 1 with expected tuner mode in tuning range. The Tuner position is measured from the DN100 CF flange.

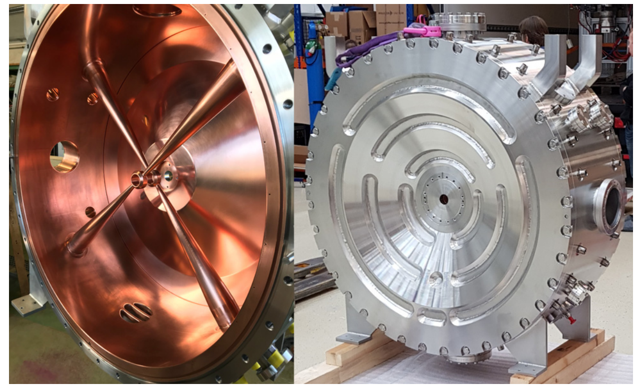

Figure 4: Photo of CH cavity 1 after copper plating (left) and ready for high power tests (right).

Cavity Tuners

Each cavity has one dynamic and one static tuner mounted horizontally. The dynamic tuner controls the resonance frequency during operation and the static tuner is fixed in length after fabrication to compensate for frequency deviation of the built cavity caused by simulation inaccuracies, structural deviations of the built model (tolerances) and varying thickness of the copper layer. The dynamic tuners are equipped with stepping motors and a potentiometer controlled by the LLRF system.

Couplers

All power couplers and pickups are inductive coupling loops made of copper. The power couplers for the CH cavities are currently in the production phase and will be available by the end of June 2018. The power couplers for the QWR cavities are placed inside a ceramic pot under atmospheric pressure separated from the vacuum inside the cavity. Each cavity has two pickups connected to the LLRF system. The pickups are in production.

BEAM DIAGNOSTICS

Diagnostic Bench

The Diagnostic Bench shown in Fig. 5 is used for the commissioning of the Linac up to 5.9 MeV. It measures the beam properties behind MEBT-1 and each CH cavity with the diagnostic elements listed in Table 2. All diagnostic devices used in the Diagnostic Bench of the MYRRHA Injector are in the final specification phase.

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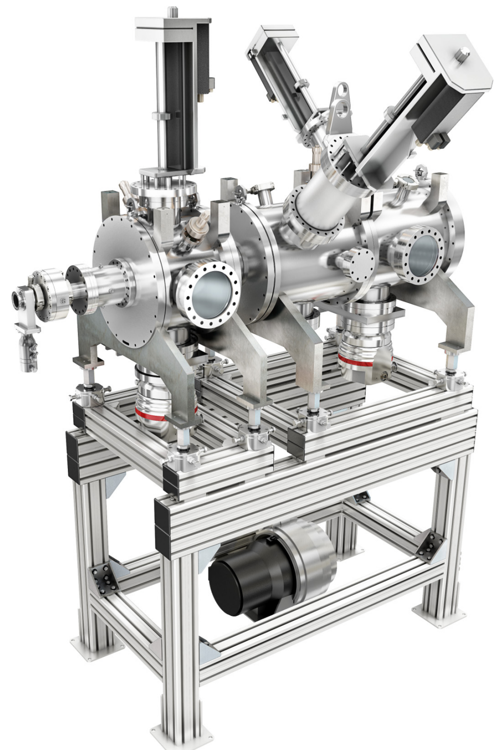

Figure 5: Setup of the Diagnostic Bench. Components on beam axis from left to right: Gate valve, ACCT, BPM, SEM, Emittance meter, BPM (hidden).

The Diagnostic Bench for the commissioning of the 4-Rod-RFQ has been modified: The Beam Spectrometer in combination with a cooled aperture is used instead of the Beam Dump and the SEM Grid and the BEM 1. This configuration is called Modified Diagnostic Bench. After the commissioning of the linac up to 5.9 MeV, the Diagnostic Bench is going to be disassembled and reused in parts in MEBT-2 and MEBT-3.

Table 2: Used Diagnostic Elements

Element	Measurement / Description
ACCT	Current measurement
4-Button BPM	Transverse position of the bunch & time of flight
SEM Grid	Transverse beam profile
Slit-Grid Device	Beam emittance
BEM (Beam Extension Monitor) [4]	Longitudinal bunch profile
Beam Spectrometer	Beam energy and fractions / Device only used in Modified Diagnostic Bench
Beam Dump	Beam Dump with ability of current measurement (Faraday Cup)

Diagnostic Elements

The BPMs (Beam Position Monitor) with a button diameter of 14 mm are used for transveral bunch position measurements (< 100 µm) behind each cavity. They can be used for TOF measurements in the commissioning phase. A second BPM type with a larger aperture is used in the Diagnostic Bench.

The Slit-Grid Emittance Meter measures the beam profile in the *xx'* and the *yy'* plane with a resolution of 0.2 mm and 0.6 mrad. It has two movable and adjustable slits (0.1 mm to 1.0 mm) and two movable grids (60x60 mm², 16 wires per plane with diameter 0.2 mm) in a distance of 350 mm.

The Beam Profile Grid (SEM) is planned to have the 0.1 mm wires made from W-Re alloy.

CONCLUSION

The design phase of the first section of the MYRRHA Injector is going to be completed in June 2018 and the second section from 5.9 MeV to 16.6 MeV will be completed in design in July 2018 [5]. It is planned to begin the commissioning phase in January 2019 with the operation of the linac up to 5.9 MeV in Louvain-La-Neuve. The MYRRHA linac up to 100 MeV is expected to be constructed by 2024 [6].

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