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PREPARATION FOR THE ADVANCED DEMONSTRATOR TESTING AT GSI

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Abstract

The superconducting (sc) heavy ion **He**lmholtz **LI**near **AC**celerator (HELIAC) is under development at GSI. As a first step, the cw-Linac demonstrator was has already been built as the first part for the proposed cw-LINAC@GSI. A superconducting CH-cavity, embedded by two superconducting solenoids has been successfully tested with beam in 2017/2018. The sc CH-structure, designed at Goethe-University Frankfurt, is the key component and offers a variety of research and development possibilities. As a next step the first cryostat of the HELIAC, the so called Advanced Demonstrator, will be tested in the same testing environment at GSI. Therefore, the testing area at GSI will be reconstructed, a bigger concrete bunker as well as the connection to the cryo plant is under development. The cold string of the former demonstrator was assembled in a rehabilitated clean room at GSI. For future clean room assemblies a fully equipped clean room is under preparation at Helmholtz-Institute Mainz. The mechanical suspension, composed of hanging components on crossed steel ropes, is a reliable concept to prevent the maximum displacement during cool down. The cryogenic systems as well as all other mechanical tasks has been specified and are going to be built. These measures and in particular the future Advanced Demonstrator preparation will be presented.

PREVIOUS BEAM TESTS AT THE DEMONSTRATOR

In 2017/2018 the first test with beam of the cw Demonstrator comprising the Crossbar-H-mode (CH) -Cavity (CH0) [1] embedded by two superconducting solenoids, was successfully accomplished [2,3]. The design goal has been exceeded and a maximum accelerating gradient of E_{acc}= 9.6 MV/m at Q_0=8.14×10^8 has been achieved [4]. In the new ISO4 class clean room at GSI the cavity was assembled together with the solenoids, as well as the power coupler and three piezo tuners. The entire cold string was assembled in a suspended frame by a crossed stainless steel rope suspension (see Fig. 1). All parts were aligned to the beam axis within a total tolerance less than 0.1 mm applying a laser tracking system. The 5 kW Rf-power coupler was conditioned in less than one day;the three piezo tuners were carefully aligned to their needed position by micro foil and measuring with digital calliper gauge. Four limit switches are hindering the tuner to move outside the limits of ±1mm, to prevent deformations or material cracks of the niobium tuning bellow inside the cavity. After closing the cryostat and its alignment on axis, the cold-warm transitions and the nearest beam pipe were heated under vacuum to increase the vacuum pressure and to remove oxygen from all surfaces as far as possible. Finally, the cryostat was cooled down and the first tests with beam started.

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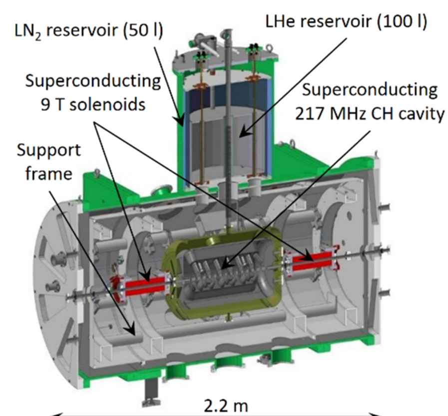

Figure 1: Sectional view of Demonstrator cryostat with the two 9 T superconducting solenoids and the CH0 cavity suspended in a support frame.

ADVANCED DEMONSTRATOR

As the next expansion stage on the way to HELIAC, a standard cryostat comprising the CH0, CH1, and CH2 cavity [5], two solenoids and a superconducting rebuncher-cavity (see Fig. 2.), mounted together on a support system consisting of eight crossed nuclotron suspensions for each component ,similar to the warm support frame of the Demonstrator suspension. The Advanced Demonstrator cryomodule will be the first part of the HELIAC, which consists of four 5m long cryomodules. The Advanced Demonstrator will be tested with beam in the area, where the Demonstrator was tested before. In straightforward direction of the GSI High Charge State Injector (HLI) (see Fig. 3). For this, the concrete bunker has to be extended and a new helium infrastructure is going to be completed supplying 4K liquid helium and 80K helium gas to the new Advanced

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Demonstrator cryostat. Another milestone is the commissioning of the new high power RF couplers, which must be easily replaceable in case of damage. A newly designed coupler with similar ceramic windows in a CF 100 flange is under development [6]. The ceramic windows can be replaced simultaneously if damaged. A prototype of the coupler will be available until end of 2019 aiming for an early testing of ceramic windows under vacuum and under low temperature (< 77K) conditions.

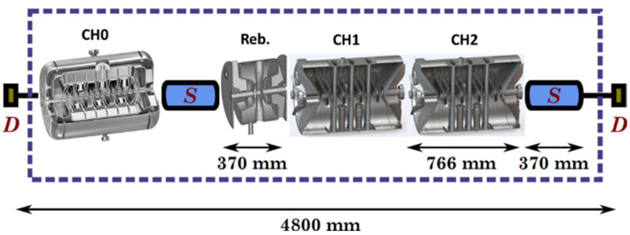

Figure 2: Standard cryomodule layout; the 5m long Advanced Demonstrator cryostat comprises three CH cavities, a rebuncher cavity, and two sc solenoids.

The cryostat is already ordered, delivery by CRYOWORLD (Netherlands) is scheduled for the year 2020. The cavities CH1 and CH2 are already fabricated by Research Instruments, Germany. First RF-testing has been already accomplished. After welding of the helium jacket and final leak testing, the cavities will be delivered at the end of 2019. The sc solenoids are in procurement, as well as the sc rebuncher.

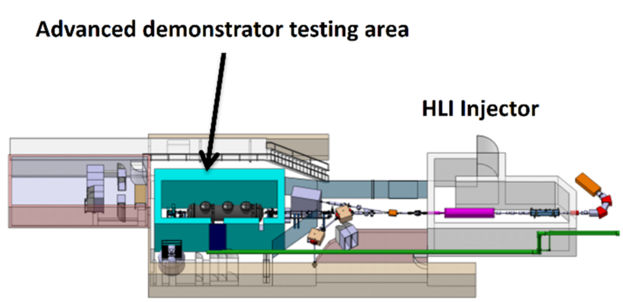

Figure 3: The Advanced Demonstrator testing area in straightforward to the GSI HLI.

The cryostat has four sufficient service ports in particular for laser tracking alignment and maintenance work. The components are mounted together within a distance of 150 mm; they are euipped with Aluminium sealing flanges. Every nuclotron suspension have to be adjustable. Inside cryostat the support frame rests on three attachment points at the bottom of the cryostat. This construction is sufficiently rigid, to prevent the suspended frame from unwanted movements. All superconducting components will be cooled by liquid helium at a temperature of 4K. The cold helium return gas has to cool the frame as well as some other components as the power couplers. A long cryogenic supply line is under construction to supply the liquid helium and the cold gas from the neighbouring liquid helium plant to the Demonstrator testing area at GSI. The concrete bunker is already extended and needs to be prepared with electric and pneumatic lines, rf pipes, nitrogen gas pipes, and analogue and digital cables. For reasons of cleanliness, the inner walls of the bunkers must be plastered and appropriately painted. Besides the bunker ground floor has even to be cleanable. Table 1 lists the design parameters of the Advanced Demonstrator.

Table 1: Design Parameter of the Advanced Demonstrator

Max A/Q		6
Resonance frequency	MHz	≈216.816
Injection energy	MeV/u	1.4
Output energy	MeV/u	2.1-2.9
Total length	m	≈ 5
CH cavities	#	3
SC solenoids	#	2
SC rebuncher	#	1

FUTURE HELIAC LAYOUT

The future variable beam energy HELIAC (3.6-7.5 MeV/u) consists of four standard cryomodules. It should consist of a total of twelve CH cavities, eight sc solenoids, and four sc rebuncher cavities (see Fig. 4) [7,8]. The total length is about 20m. It is planned to install the accelerator in the neighbouring hall segment of the existing HLI /STF-hall). To provide cw beam operation at the HELIAC RFQ and IH cavity have to be upgraded in the near future. The total lenght of the concrete radiation protection shelter will be about 40m. The ground floor of the STF hall has to be prepared to hold the load of the radiation protection shelter. Also the whole infrastructure supply has to be planed carefully.

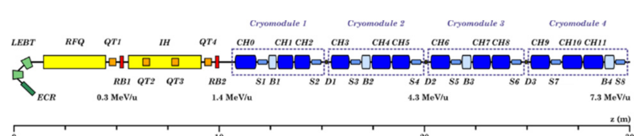

Figure 4: HELIAC accelerator layout.

OUTLOOK

The CH1 and CH2 cavities are about to be tested in 2019. A complete string of dummies will be manufactured for cleanroom assembly, alignment, and cold testing of the Advanced Demonstrator in 2020. The final beam tests will start in end 2020/ early 2021. After successful testing the preparation for the future HELIAC will start immediately. The Advanced Demonstrator testing area will be used for future HELIAC cryomodule testing The clean room environment at HIM serve the assembly of each module under clean room condition, and a final RF-testing in the located rf testing bunker [9].

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