RECENT STATUS NEW SUPERCONDUCTING CW HEAVY ION LINAC@GSI

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Abstract

The demonstrator is a prototype of the first section of the proposed cw-LINAC@GSI, comprising a superconducting CH-cavity embedded by two superconducting solenoids. The sc CH-structure is the key component and offers a variety of research and development. The beam focusing solenoids provide maximum fields of 9.3 T at an overall length of 380 mm and a free beam aperture of 30 mm. The magnetic induction of the fringe is minimized to 50 mT at the inner NbTi-surface of the neighboring cavity. The fabrication of the key components is still in progress and is near to completion. After cold performance testing of the RF cavity, the helium jacket will be welded on. The cryostat is partly assembled and will be finished in the next weeks. The test environment is completely prepared. Advanced emittance measurement is foreseen to prepare for best matching of the heavy ion beam from the injector. Integration of the cryostat into the beam line, the first cool down of the module and commissioning of the RF elements will be performed as next steps towards a complete testing of the demonstrator.

CW LINAC DEMONSTRATOR

The Demonstrator project kick-off at GSI was in 2010, which was followed by design studies for the 217 MHz CH cavity, two sc solenoids, and the cryostat. Meanwhile the fabrication is near completion. The main parameters are listed in Table 1.

The concept of a suspended support frame, which carries the cavity embedded by two sc solenoids, was chosen (Fig.1) [1]. The support frame as well the accelerator components are suspended each by eight tie rods in a cross-like configuration (nuclotron suspension) balancing the mechanical stress during the cooling-down and warm up (Fig.2). This way the components will stay always within the tolerance limits related to the beam axis (longitudinal ±2 mm, transversal ±0.2 mm).

Cryogenic Limited (UK), assembled already the cryostat, the solenoids, the support frame, and the helium supply. After mounting and cool down tests, the cryostat will be delivered to GSI in end of 2015 (Table 2).

Table 1: Main Parameters

CH-Cavity		
β		0.059
max A/Q		6
Resonance Frequency	MHz	217
Gap number		15
Total length	mm	690
Cavity Diameter	mm	409
Aperture	mm	20
Effective gap voltage	kV	225
Accelerating gradient	MV/m	5.1
Cryostat		
Inner length	mm	2200
Inner diameter	mm	1120
Material		Al
Operating temperature	°K	4.4
Operating pressure above atmosphere	bar	< 1
Solenoids		
Aperture	mm	30
Total length	mm	380
Max. field	T	9.3
Nominal current	A	110

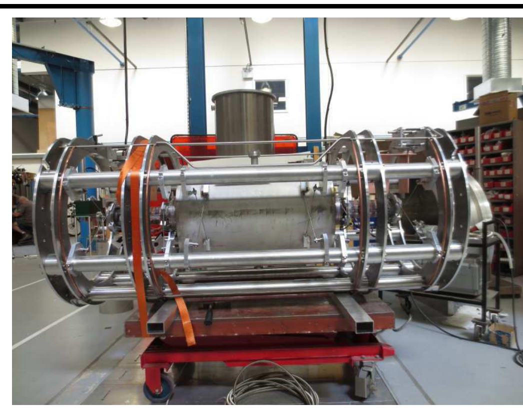

Figure 1: The cw Demonstrator comprising, a CH-cavity embedded by two solenoids supported by a frame, inside the cryostat.

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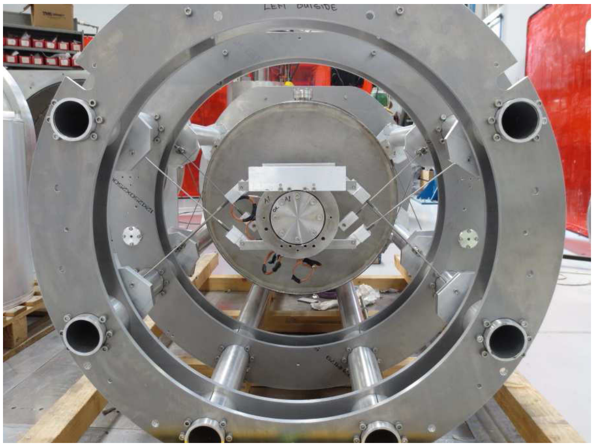

Figure 2: Detailed view of tie rods in a cross-like configuration.

The layout of two solenoids has particular features: A configuration of a main coil (NbSn) and two (NbTi) compensation coils reduces the maximum magnetic field of 9.3 T within 10 cm to acceptable 30 mT at the position of the neighbored cavity. The solenoids are connected to LHe pots inside the cryostat by copper tapes allowing dry cooling. (Fig.5)

The CH cavity is directly cooled by LHe using a He jacket out of titanium. The manufacturer is Research Instruments (GER). The delivery is expected at the end of 2015, after a final preparation by high pressure rinsing (HPR), and a last performance test at 4K with low rf power @ Goethe University, Frankfurt [2].

Three piezo tuners manufactured at GSI Workshop are foreseen to tune the cavity during operation. Therefore a tuner dummy was already tested [3].

Figure 3: Loading/unloading the cryostat with an aluminum frame.

SETUP AT GSI HLI

Commissioning of the Demonstrator is planned in 2016 at the GSI HLI, which operates at 108 MHz (Fig.4). A new transport beam line in straightforward direction from the HLI, to the new Demonstrator radiation protection shelter, was designed regarding beam dynamical simulations [1].

In June 2015 an emittance measurement at the future position of the demonstrator cryostat confirmed the latest beam dynamic simulations and the aspired positioning of the components in the beam transport line [4].

The 3000 ltr. Reservoir and the 12 kW Amplifier for a second 108 MHz Buncher in for improving longitudinal matching is already in place and ready for mounting. A flexible 13m long helium pipe will be connected to the demonstrator cryostat. The exhaust helium gas will be connected to a 25m³ recovery balloon and afterwards liquefied and brought back.

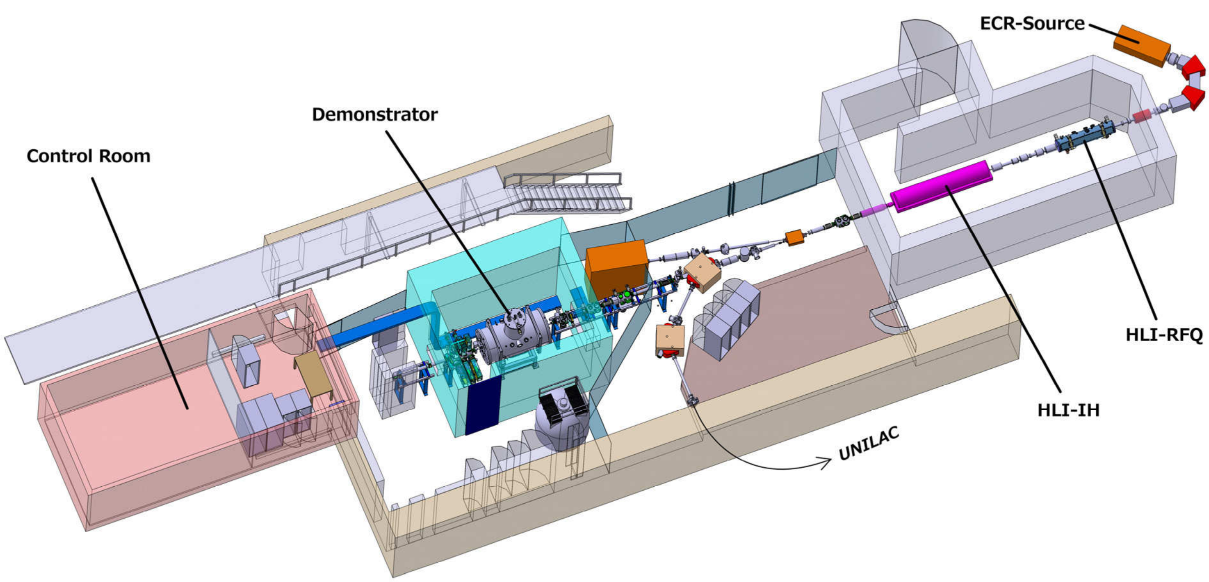

Figure 4: 3D layout of the GSI High Charge State Injector with the new cw-LINAC Demonstrator environment.

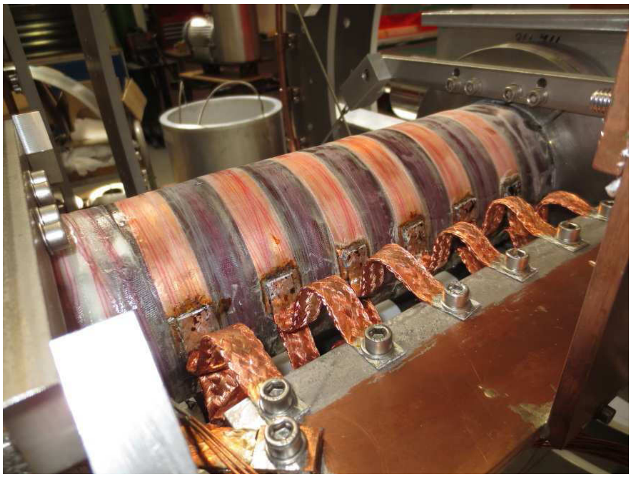

Figure 5: Dry cooled solenoids.

Enabling the mounting of the demonstrator string under cleanroom conditions, and also for future service of other applications, an existing ISO 8 cleanroom at GSI planned to be upgraded to ISO 4 till the end of the year 2015.

Furthermore the design of the power coupler is completed and will be ordered soon. The expected manufacturing time is 15 weeks from the day of order.

A loading/unloading design was elaborated with Cryogenic Ltd. A transport frame was designed to mount and unmounts the string with support frame to the cryostat (Fig. 3).

TIMETABLE

Table 2: Timeline

	cw-LINAC Demonstrator-Project
2010	Kick-off at GSI Tendering of demonstrator components
2011	Delivery of LHe-supply and rf-amplifier Ordering of cavity, solenoids, cryostat Assembly of test area @GSI started
2015	Delivery of cavity 1st tests (warm + cold) at IAP
2015	Delivery of solenoid and cryostat
2016	Full performance test at GSI HLI

OUTLOOK

The Demonstrator project is a proof of principle on the CH cavity. Successful full performance tests with beam of the sc CH-cavity open a broad field of accelerator applications, e.g.:

- The first 360 MHz prototype was developed within EUROTRANS (European research program for the transmutation of high level nuclear waste in an accelerator driven system). The follow-up project, MYRRHA, is planned to be commissioned in 2023. Four 176 MHz sc CH cavities are integrated into the accelerator driven system (ADS) [5].
- Another future application is the sc cw-LINAC at GSI [4]. Especially the Super Heavy Elements (SHE) program at GSI and at the Helmholtz Institute Mainz (HIM) benefits highly from such a dedicated accelerator. As a next step the extension of the Demonstrator to a string of five 217 MHZ CH-cavities is proposed (advanced Demonstrator) (Fig.6) [6].

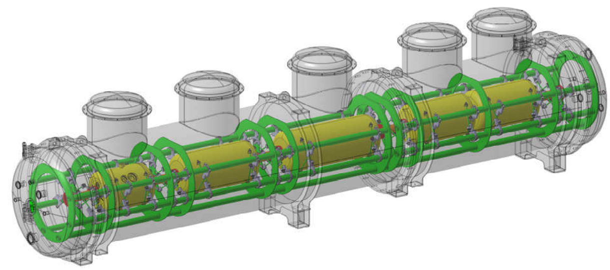

Figure 6: Draft version of a multi cavity advanced demonstrator layout.

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