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# 1.3 GHz SRF CRYOMODULES FOR THE MAINZ ENERGY-RECOVERING SUPERCONDUCTING ACCELERATOR MESA*

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*Abstract*

The Mainz Energy-recovering Superconducting Accelerator MESA requires superconducting RF systems that provide sufficient energy gain of 50 MeV per turn to an electron beam. The order of two Rossendorf-type cryomodules, containing two 9-cell 1.3 GHz XFEL-like cavities each, has been placed. Besides an overview of the adaptations required for the multipass and high current beam operation of the cryomodules, details about challenges regarding the installation of the cryomodules on the premises of the Institut für Kernphysik at Universität Mainz are given.

## INTRODUCTION

Superconducting Radio Frequency (SRF) is a key technology for the Mainz Energy-recovering Superconducting Accelerator MESA. The both-sided SRF main linac will provide an energy gain of 50 MeV per turn, hence 12.5 MeV per cavity, as the cryomodule of choice is the Rossendorf-type cryomodule [1] containing two 9-cell TESLA/XFEL-type cavities. The complex structure of cryomodules containing the niobium cavities and its exterior parts require adaptions to each indiviual use. So the Rossendorf-type modules will undergo modifications as described in the following section. Further on the installation of the cryomodules at their dedicated spot in the MESA caverns requires detailed planning as construction work is needed. The plans for the installation will be presented in the subsequent section, followed by an outlook.

## ROSSENDORF-TYPE CRYOMODULES

The Rossendorf-type cryomodules are well-characterised and in use at HZDR for more than a decade. A picture of one of the installed modules is shown in Fig. 1. Since then smaller adaptations have been applied to the design for easier assembly and better performance by the manufacturer Research Instruments GmbH [2]. These include an improvement of the liquid nitrogen shield and the use of niobium cavities undergoing the European XFEL preparation process [3].

For the purposes of MESA some additional changes will be applied. The Higher Order Mode (HOM) couplers will contain sapphire feedthroughs, improving the thermal conductivity and thus push the thermal breakdown of the superconducting HOM coupler antenna tip to a higher performance level.

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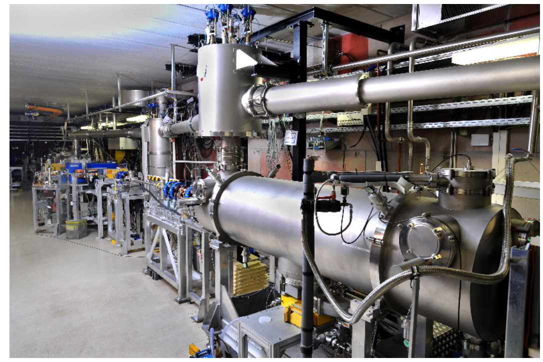

Figure 1: ELBE cryomodule (©Frank Bierstedt).

Due to the small bandwidth of the superconducting RF cavities, microphonics will be an issue for the energy recovery operation mode of MESA. To keep the frequency of the cavities under control, even for fast frequency changes, the tuner requires piezo technology which is not included in the standard Rossendorf type tuner and has to be replaced. Following from the tuner change, some redesign of the cavities' helium vessel is required. Besides the adaptations of the cryomodule, the coldboxes for the 4 K/2 K liquid helium (LHe) production including control system will also be provided, therefore only a $T = 4$ K LHe liquefier and the subatmospheric pumping units have to be provided by the institute.

## SPACE CONSTRAINTS

In contrast to other projects, the facilities for MESA are already available, as they have been in use for a former experimental setup at the MAMI [4] accelerator. As these buildings are about 10 metres underground, the space foreseen is strictly limited, causing challenges in placing the lattice and all accelerator subsystems [5]. Special issues have to be faced for the cryomodules, as the current lattice places the cryomodules partially in apertures of the approx. 3 metres thick walls between the two accelerator halls MESA A/B. The front view sketch of the apertures and simplified insertions are shown in Fig. 2.

While the cryomodules itself fit into the apertures, the electric connections and the piping for the coolants will be an issue. The waveguides required for the RF supply reduce the space available for maintenance work and obstruct the passage to the end of the cryomodule which is located in the walls' aperture. Due to static reasons, a pedestal is required which will create a dead end, see Fig. 3.

In addition the cabling for RF and temperature diagnostics also hinders the transit, as the shearing forces applied might



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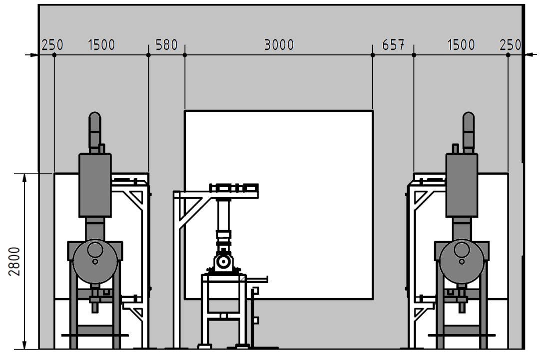


Figure 2: Sketch of the front view of the walls including the apertures for the cryomodules and the injector linac. The width of the cryomodules is approx. 1.0 m

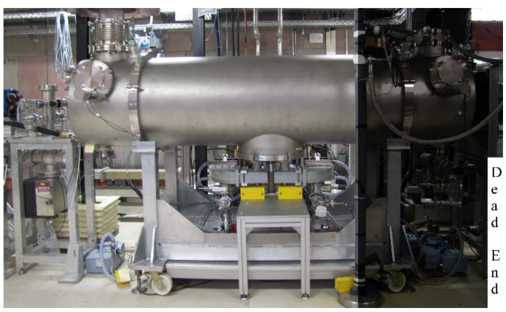


Figure 3: Composite photograph with side view of an ELBE cryomodule (overall length 3.3 m) with a shaded area showing the insertion depth of the cryomodules into the wall at MESA. The area of the wall openings cannot be increased because that would jeopardize the statical integrity of the building. The middle opening contains the normal conducting injector Linac and furthermore creates the only possibility to transport components between the two MESA halls.

damage the connectors or even the vacuum feedthroughs if the cables are touched due to the limited space (see Fig. 4).

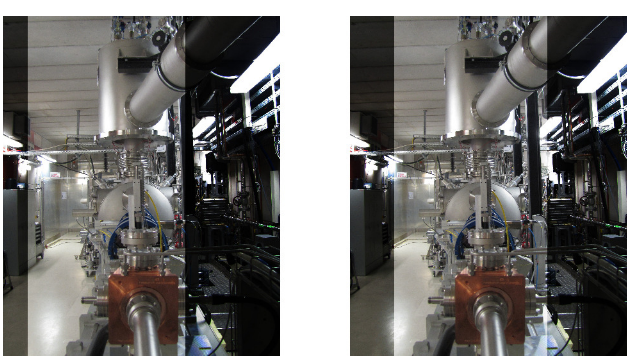

Figure 4: Composite photographs with front view of the ELBE cryomodules. The shaded areas refer to the respective position of each of the two cryomodules foreseen for MESA.

For the alignment of the cryomodule and the cryogenic string within the module access to the 'dead end' is a mandatory requirement, or the supports have to be prepared in advance to allow remote control. The piping for the cryogenic supply is not yet fixed, but it may reduce the clearance within the apertures. To perform installation and maintenance work from the top the installation of a platform upon the cryomodule is the only option. This will not be possible if the helium pipe has to pass the aperture. Still without the piping the headroom will already be narrow with 0.8 m.

## SOLUTION

The present solution of these issues is shown in Fig. 5, which displays the current layout of the MESA accelerator within the caverns. To avoid most of the issues regarding space, the accelerator will be moved partially into the experimental hall and the cryomodules will be easily accessible, as they are no longer placed in the walls' aperture. The increased space requirement would lead to a considerable reduction of the experimental possibilities. However, at present (Spring 2015), it seems very probable that a significant extension of the facility by another experimental hall will be granted. This would allow to perform all planned experiments at MESA while even offering a further extension of the MESA lattice for instance by an introduction of longer cryomodules with more SRF cavities.

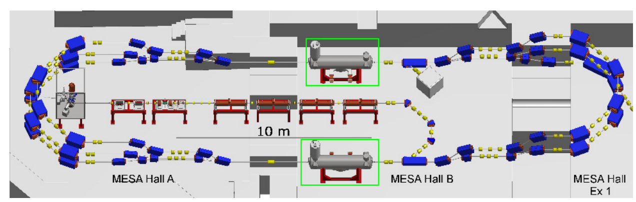


Figure 5: Overview of MESA. The cryomodules are highlighted (green).

## SUMMARY

MESA will be the first multiturn SRF ERL. The potential advantage of converting existing buildings for the MESA accelerator causes challenges for the lattice and especially for the complex SRF cryomodules. The issue limited available space within the 3 m thick walls has been resolved by an extension of the lattice by about 4 m. This allows to remove the modules from the ctritical wall-area, the assembly of the more conventional components which replace the SRF components is feasible. The increased length of the orbit can be handled within the given space constraints. This simplifies the connection of several subsystems, the alignment process and maintenance work.

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## REFERENCES

[1] J. Teichert et al. "RF status of superconducting module development suitable for CW operation: ELBE cryostats." In: *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 557.1 (2006). Energy Recovering Linacs 2005 Proceedings of the 32nd Advanced ICFA Beam Dynamics Workshop on Energy Recovering Linacs 32nd Advanced ICFA Beam Dynamics Workshop on Energy Recovering Linacs, pp. 239–242. ISSN: 0168-9002. DOI: http://dx.doi.org/10.1016/j.nima.2005.10.077. http://www.sciencedirect.com/science/article/pii/S0168900205020000

[2] www.research-instruments.de

[3] D. Reschke, L. Lilje, and H. Weise. "Analysis of RF results of recent nine-cell cavities at DESY." In: *Proceedings of the 14th international conference on RF superconductivity*. 2009.

[4] M. Dehn et al. "The MAMI C accelerator." English. In: *The European Physical Journal Special Topics* 198.1 (2011), pp. 19–47. ISSN: 1951-6355. DOI: 10.1140/epjst/e2011-01481-4. http://dx.doi.org/10.1140/epjst/e2011-01481-4

[5] D. Simon et al. "Lattice and Beam Dynamics of the Energy Recovery Mode of the Mainz Energy Recovering Superconducting Accelerator MESA." In: *Proceedings of the 2015 International Particle Accelerator Conference (IPAC 2015)*. 2015.

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