THE SRF PHOTO INJECTOR AT ELBE - DESIGN AND STATUS 2013

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Abstract

In order to improve the gradient of the cavity and the beam quality of the gun, a new design for the SRF photo injector at the Helmholtz-Zentrum Dresden-Rossendorf has been developed. Apart from the special design of the cavity itself – as presented at SRF09, Berlin – the next update will include a separation of input and output of the liquid nitrogen supply system. This is supposed to increase the stability of the nitrogen pressure and enable a better monitoring of its temperature. The implementation of a superconducting solenoid inside the cryomodule is another major improvement. The position of this solenoid can be adjusted with high precision using two step motors, which are thermally isolated from the solenoid itself. The poster will present the progress of turning the first design models into reality.

INTRODUCTION

The Rossendorf superconducting RF photo injector (SRFgun) developed within a collaboration of the institutes HZB, DESY, MBI and HZDR has been put into operation in 2007. It is designed for medium average current beam and operation in CW mode with high repetition rate [1]. The superconducting cavity, the main part of SRF gun, consists of three TESLA cells and one optimized half-cell. The Cs_2Te photocathode is inserted in the half cell isolated by a 1mm vacuum gap. Additionally, a resonant superconducting choke filter surrounding the cathode is served to prevent RF leakage. During the gun operation, the cavity quality limits the achievable acceleration gradient and thus the electron beam parameters could not approach the design values [2]. For that reason two new niobium cavities were fabricated and treated in collaboration with Jlab. Simultaneously a new cryomodule was designed and fabricated.

DESIGN OF THE NEW CRYOMODULE

The design of the new cryomodule for the SRF gun upgrate is shown in Fig. 1. The stainless-steel vacuum vessel has a cylindrical shape with 0.73 m diameter and 1.3 m length. The cavity is passively protected against ambient magnetic fields by means of a µ-metal shield, placed near the inside of the vacuum vessel. The thermal shield is cooled with liquid nitrogen. It consists of a cylindrical Al sheet welded to two circular tubes filled with N2. The liquid N_2 tank is in the upper part of the cryomodule. From the N_2 tank tubes lead to the photocathode cooler and the main power coupler. Eleven Ti spokes hold the cold mass (cathode cooling and support system, He tank with cavity, superconducting solenoid) and allow a precise alignment of the cavity by means of micrometer screws from outside. The He port and the N2 port are on top of the cryomodule. From the port the He flows through a heater pot and the two-phase supply tube into the chimney of the He tank. The cryomodule is designed for superfluid He at 2 K (31 mbar) and RF operation in continuous wave mode with a heat losses of up to 50 W. The static He head load is about 5 W. There are two He level sensors, one in the He tank and one in the heater pot. The later and an electrical heater serve for the He level control in the cryomodule. Three rotary feedthroughs at the backside allow an adjustment of the photocathode with respect to the niobium cavity.

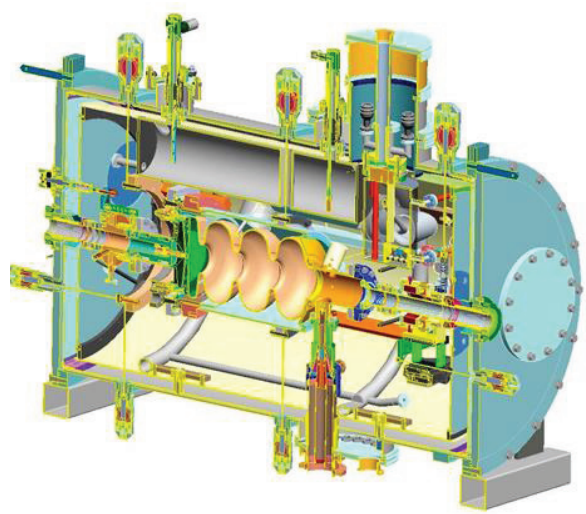

Figure 1: 3D cut view of the new cryomodule.

The main difference of the new cryomodule to that of the present operating SRF gun is the integration of a superconducting solenoid. Furthermore the liquid N_2 filling level measurement has been improved. The cryomodule was assembled without the Nb cavity and tested in 2013. Fig. 2 shows a photograph.

INTEGRATION OF THE SUPERCONDUCTING SOLENOID

The superconducting solenoid consists of a coil with NbTi wires and a soft iron joke. It can produce a peak field of 0.45 T with a 10 A current. The inner boring diameter is 60 mm. A Cu plate with a U-shaped tube in it cools the solenoid with liquid He. Flexible tubes realize the connection to the He heater pot.

Figure 2: Photograph of the new SRF gun cryomodule.

The solenoid and the cavity must be precisely aligned to each other. Therefore the solenoid support is connected to the cavity tank with three stable rods (see Fig. 3). A first mechanical alignment of the solenoid is carried out during the assembly. Thereby the solenoid have to tilt correctly in order that it axis is parallel to the cavity axis. After cooling down, a remote controlled, beam based alignment procedure will be applied for horizontal and vertical positioning. The solenoid is placed on an x-y table with two stepper motors. The position system of PI miCos GmbH is suitable for use in vacuum and at cryogenic temperatures. The traveling range is 6 mm for both directions. The traction current as well as the permanent holding current of the stepper motor causes a heat input which was expected to be too high for the He system. Therefore the x-y table is on 70 K and cooled with liquid N_2. This solution requires its thermal isolation with respect to the He cavity vessel and the solenoid. The photograph in Fig. 4 shows the realized technical design with the superconducting solenoid, its He cooling connections, the solenoid mount, and the x-y table with stepper motors.

Within a functional test the cryomodule was completely assembled with exception of the Nb cavity, evacuated and cooled with liquid N_2 and liquid He (4 K). The He colling of the SC solenoid worked properly and the field profile could be measured at the nominal current of 10 A [3]. Furthermore, the operation of the operation of the stepper motors at 70 K temperature was tested. With a number of temperature sensors the proper thermal isolation between He vessel, x-y table, and SC solenoid was checked.

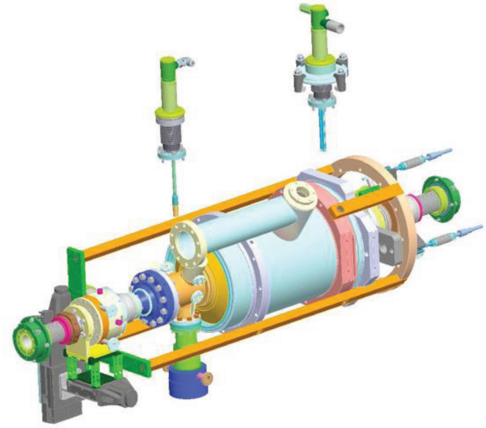

Figure 3: Drawing of the cold mass, from left to right: Beam tube, x-y table, stepper motors and superconducting solenoid, liquid He vessel of the cavity, photocathode cooling system, vacuum tube for cathode exchange.

NEW CAVITIES

During the last years two new Nb cavities for the SRF gun has been fabricated, treated and tested in collaboration with Jlab. One of them has been completed with the He vessel as can be seen in Fig. 5. In comparison to the existing SRF gun at ELBE the new cavity will have a higher performance with respect to the intrinsic quality factor and the maximum acceleration gradient.

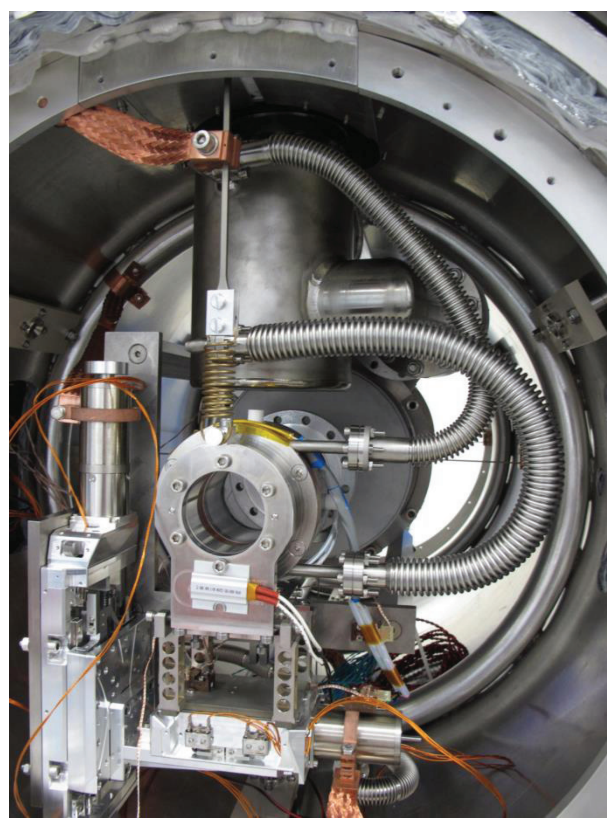

Figure 4: Photograph of superconducting solenoid after assembly in the new cryomodule.

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The new cavity has 3½ cells and is in its shape similar to the existing one. Some improvements concern the higher stiffness of the half-cell and a modified design of the choke filter pick-up antenna (see Fig. 6) [4]. After a final performance test it is planned to assemble the cold mass in the Jlab clean room, and after that to ship it to HZDR for final cryomodule assembly.

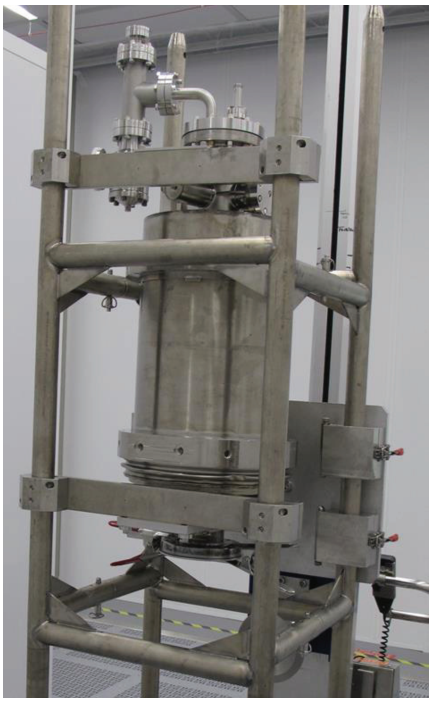

Figure 5: Photograph of SRF gun cavity with He tank before the vertical test.

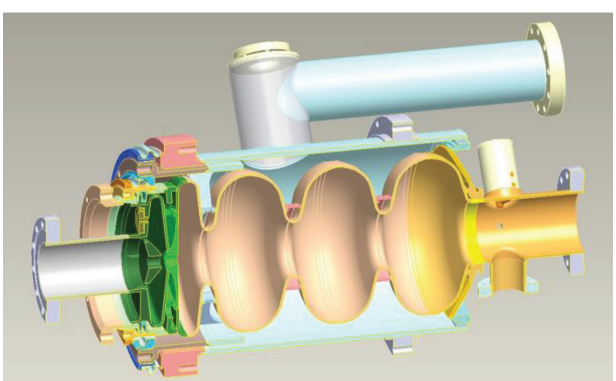

Figure 6: Drawing of the 3½ cell SRF gun cavity.

PHOTOCATHODES

In 2013 a new photocathode laboratory was established and put into operation in the ELBE accelerator building. It consists of a laboratory room and a class 100 clean room. The existing preparation system for Cs_2Te photo cathodes was moved into the new laboratory. The photo cathode diagnostics has been upgraded to allow multi wavelengths quantum efficiency measurements. The future work on Cs_2Te photo cathodes will be focused on the suppression of multipacting. A new preparation system for GaAs photocathodes (see Fig. 7) is being built to allow the use of these photocathodes at the SRF gun in future.

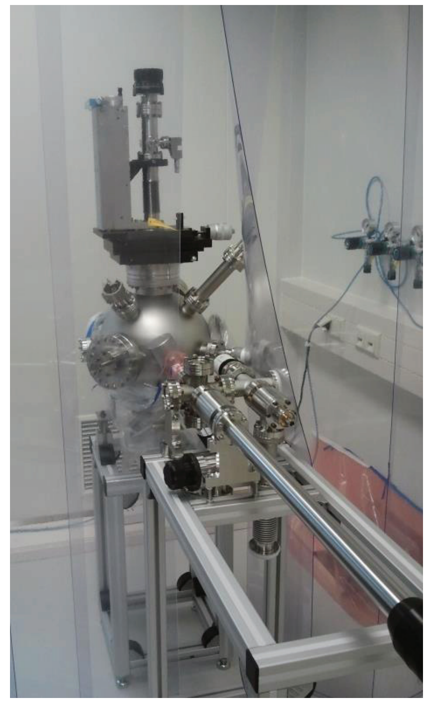

Figure 7: Photograph of the new preparation system for GaAs photocathodes.

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