

THE SRF MODULE DEVELOPMENTS FOR BESSY VSR

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Abstract

Helmholtz-Zentrum Berlin is developing BESSY VSR, a novel upgrade of the BESSY II facility to provide highly flexible pulse lengths while maintaining the average flux and brilliance of BESSY II [1]. The project goal is to simultaneously circulate both "standard" (some 10 ps long) and "short" (ps and sub-ps long) pulses offering the BESSY user community picosecond dynamics and high-resolution experiments. The concept relies on the installation of high-voltage SRF cavities operating at the 3rd and 3.5th harmonics where the beating of the two frequencies provides RF buckets for long and short bunches. Since these cavities will operate in CW and with high beam current (300 mA), the cavity design represents a challenging goal when needing to avoid coupled bunch instabilities (CBI's). The installation of the VSR cryomodule must fit in one of the available 4-m long low beta straights. On this paper recent findings as well as project scope re-definitions are addressed together with the related technological and engineering techniques. The present SRF developments are shown, including the cavities, higher-order mode absorbers and the cryomodule cold-string design.

INTRODUCTION

Since the VSR module is designed to run CW with a 300mA high current beam consisting of a quite exotic filling pattern, impedance control plays a key role when avoiding CBIs [2]. For this reason the longest low β straight section in the BESY ring represents the only feasible module location. Recently the cavity design was changed from a 5-cell to a 4-cell cavity as it became clear that the available space was insufficient to accommodate the original design. As a result the total module voltage drops in 20% (29.71 MV) with respect to the original 37.2 MV originally specified for BESSY VSR. As a consequence a 10% reduction in the expected VSR bunch compression is obtained. That is a VSR short bunch length of 1.87 ps instead of 1.7 ps for the standard BESSY optics.

COLD STRING DEVELOPMENTS

Several important issues have been recently identified such as HOM power damping or synchrotron light effect. The implemented design actions taken to mitigate those effects are presented on this paper.

HOM Power Damping

The first of these measures related to optimize the module length was to reduce the number of cells per cavity (Fig.1). This change will result in a 15% reduction on total HOM power and as well as improve the damping capabilities of the cavities. After the EM validation of the new shortened cavity version, power propagation studies through the module were performed. Figure 2 shows a full layout of the studied BESSY VSR cold-string. Even though the HOM cavity end-groups are highly effective in damping most of the generated HOM power ($\approx 75\%$) there is still an important HOM contribution travelling up-downstream. This sum of the total upstream/downstream power is roughly 1.5KW [3]. Therefore and in order to avoid some of this power to propagate to the BESSY ring or to be reflected towards the module a set of two new warm beam-pipe absorbers is designed (see Fig.3). These are inspired on the SiC Coorstek SC-95 design developed by Argonne [4]. As it can be seen from Fig.3 the design is extremely shortened in order to include a pumping dome as well as the required taper to the BESSY ring cross section.

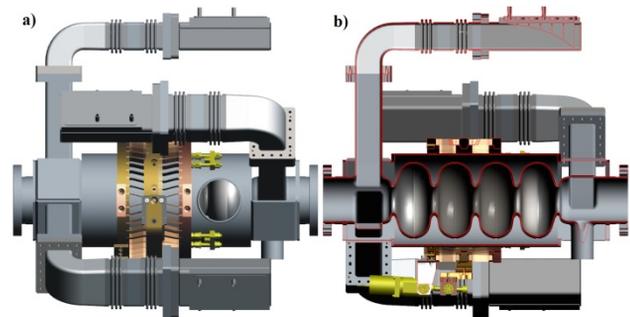


Figure 1: 4-cell 1.5 GHz Cavity design equipped with He-vessel and blade tuner (a). Cut plane view showing WG HOM loads design details (b).

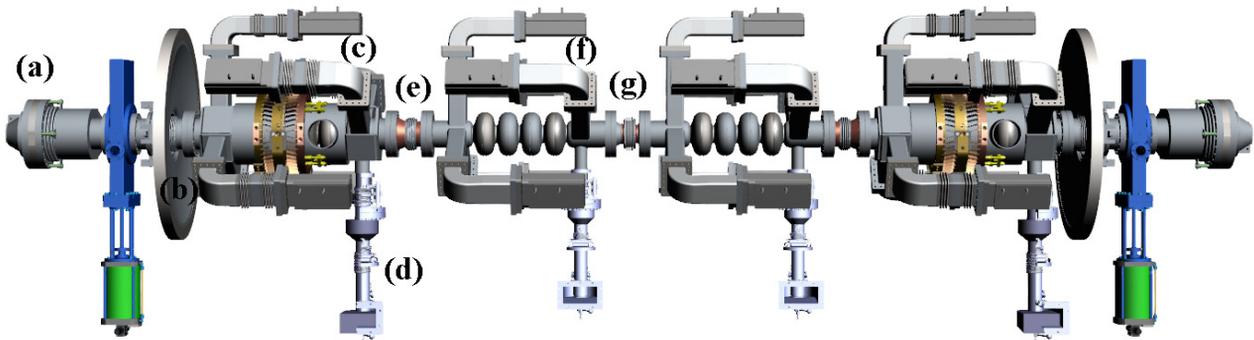


Figure 2: The BESSY VSR cold-string. Components named (left to right): Warm beam-pipe absorber including taper and pumping dome (a). Warm/Cold transition bellow (b). 1.5 GHz cavity with He vessel and blade tuner (c). 1.5GHz 16 KW HPC (d). Shielded bellow (e). Undressed 1.75 GHz cavity (f). Collimated shielded bellow (g).

As in the case of the original VSR 5-cell cavities [5], the main HOM damping is performed by means of 20 warm water-cooled WG HOM loads. These SiC loads are specified to handle a total amount to 460 W (10% overhead included) per load at room temperature. The design of these loads is being performed in collaboration with JLab. The first prototypes are currently under fabrication and will be shortly tested [6]. A detailed view of the load design and the calculated temperature on the absorbing tiles is shown in Fig. 4.

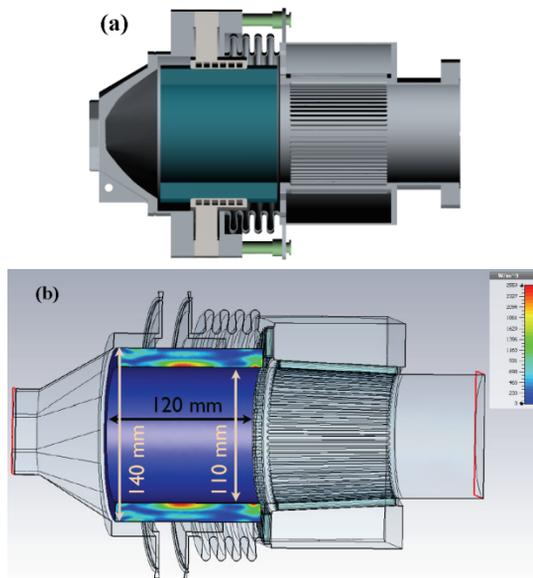


Figure 3: CAD view of the designed warm beam-pipe load (a). EM eigenmode calculations on deposited power densities (b).

Synchrotron Light

Recent calculations on synchrotron light trajectories show that an significant amount of the light emitted from the nearest downstream magnet section will collide at several cold-string spots (1.8K environment) such as cavity irises. This strong power contribution (89W) must be controlled since just a small fraction would be suffi-

cient to induce a quenching process. In order to cope with this problem collimators are introduced. A first warm collimator placed at the upstream quadrupole prior to the module entrance takes care of absorbing most of the incident light power (63 W) and leaving some light to travel to the bellow section in the centre of the cold-string (11 W). The remaining light contribution leaves the module without hitting the cold-string walls. Due to the reduced space available new multipurpose cold-string elements are currently under design. In particular this centre bellow section between the two 1.75 GHz cavities is being re-designed in order to act as a collimating structure by means of its first copper plated steep taper section. Fig.5a shows the calculated temperature rise after the contact with the colliding light spot. As inferred from the picture this component includes a capacitive gap in order to shield the bellow from the fundamental power leaked from the cavities in the vicinity. Cooling channels are inserted at both sides providing the necessary 5K intercepts.

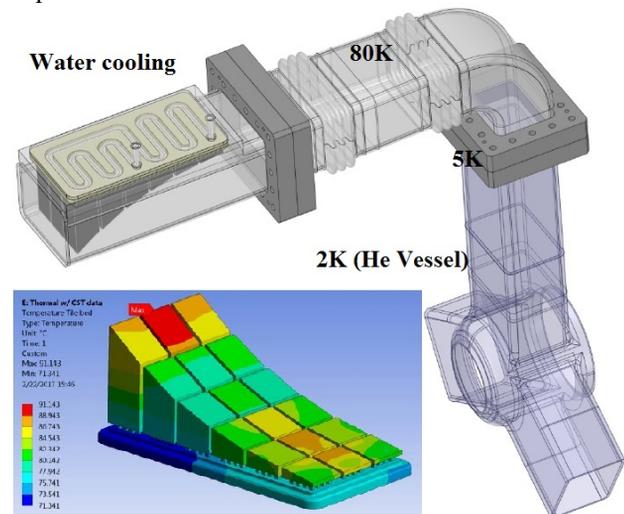


Figure 4: Water-cooled HOM WG loads with calculated temperature rise due to HOM power spectrum (Courtesy of F. Fors, Jlab). Tmax=91°C for 460W input power.

Since all of the presented elements could be a potential source for unexpected extra impedances with harmful effects on the beam quality, special care is taken on the impedance calculations for the whole VSR cold-string. Therefore wake-field full string computations are performed in CST [7] to determine the possibility of introducing harmful instabilities. The different components are in addition carefully analysed through its eigenmode spectrum to determine their feasibility with respect to HOM resonances and collision with synchrotron frequencies. Figure 6 shows a calculated impedance spectrum for the designed VSR string. In addition, a collaboration with Rostock University is established in order to perform further studies on the concatenated string by means of the State Space Concatenation technique (SSC) [8].

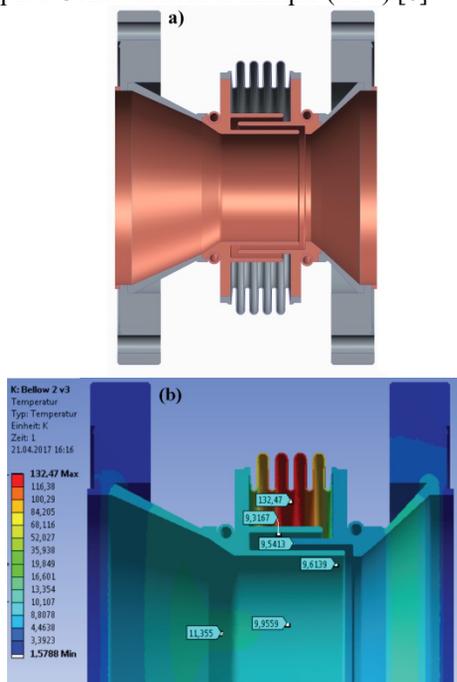


Figure 5: CAD view of the collimating shielded-bellow design (a). Cooling channels are 5K intercepts. Temperature distribution induced by the incident light. The 11.35K light green area corresponds with the synchrotron light impact point. Heat load on the below section is a result of the fundamental mode leaked power (b).

In order to validate the numerical results and discard unexpected sources of impedance HZB will fabricate a first prototype of the collimated-bellow component for beam tests at BESSY II. Further tests of different elements such as the warm beam-pipe absorber are also foreseen.

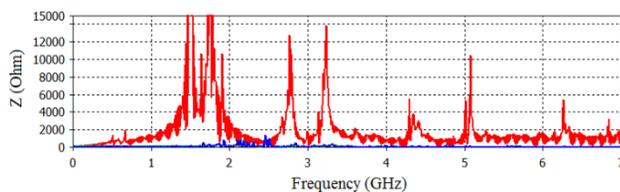


Figure 6: Calculated longitudinal (red) and transverse (blue) impedances for the full BESSY VSR cold-string. Beam harmonics are multiples of 500 MHz and 250 MHz for the “Baseline” and “Extended” baselines [3].

High Power Couplers & Prototypes

All independent 3 and 3.5 harmonic cavities will be equipped with a 16 kW CW HP coupler [9]. The design of this coupler is currently under development at HZB and it is based on the Cornell Injector coupler design [10]. Details on the design status for this coupler are presented in [11].

As it was previously introduced, the new development of several string components and damping techniques (WG damped cav.) makes the fabrication of prototypes necessary in order to validate the designs. To this end a 5-cell copper WG-damped cavity and a single-cell Niobium cavity are currently under fabrication at Research Instruments (RI) (Fig.7). As inferred from the picture the WG ends of the Nb single-cell prototype are closed with Nb blind flanges in order to fit into HZB small vertical test stand.

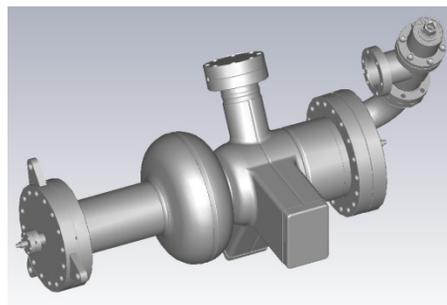


Figure 7: 3D CAD view of the 1.5GHz single-cell cavity prototype under fabrication.

CONCLUSIONS

The present paper shows the status of the VSR cold string and the new developments done in order to deal with HOM power and synchrotron light concerns. Results show the feasibility of fulfilling the challenging space constraints while keeping reliable SRF operation and beam standards. Prototypes tests and beam tests will be performed to validate these results.

ACKNOWLEDGEMENT

Authors would like to M. Ries and M. Scheer for their calculations on BESSY II synchrotron light powers and trajectories.

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