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PROGRESS OF THE BESSY VSR COLD STRING DEVELOPMENT AND TESTING*

H.-W. Glock†, V. Dürr, F. Glöckner, J. Knobloch, M. Tannert, A. Velez, D. Wolk, N. Wunderer
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB), Berlin, Germany
J. Guo, H. Wang, R. Rimmer, Thomas Jefferson National Accelerator Facility (JLab), Newport News, VA, USA

Abstract

The so-called VSR (Variable Storage Ring) upgrade of the 3rd gen. light source BESSY II will provide the capability to simultaneously store long (about 20 ps rms length) and short (1 ps or less) bunches in the ring. This will be accomplished by inserting a module with four superconducting cavities, two of them operating at 1.5 GHz as the third harmonic of the 500 MHz driving RF, two at 1.75 GHz. The "cold" string of those four cavities also includes supporting and connecting devices, as there will be: - three intermediate bellows, all shielded against leaking fundamental mode cavity fields, one additionally acting as a collimator for incident synchrotron light; - two tuneable bellows at the module ends; - two warm end groups outside the module, housing toroidal dielectric wake field absorbers, another bellow and a vacuum pump connection. The recent design progress of those components will be reported, including a description of a beam test planned for the central collimating shielded bellow.

"COLD" STRING SET UP

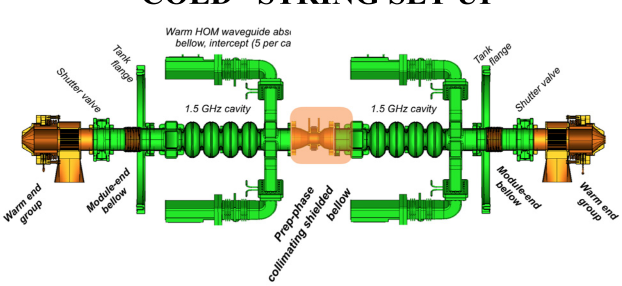

Figure 1: Prep(aration) phase VSR cold string set up, featuring only two 1.5 GHz cavities and a modified central bellow, otherwise being identical to the final module set up (cf [1], Fig. 1).

The BESSY II VSR upgrade [2] will give the opportunity to store long and short bunches simultaneously in the ring, providing alternating buckets with strong and very weak longitudinal E-field slope. This will be achieved by the superimposed effect of two kinds of superconducting cavities, oscillating on the 3rd and 3.5th harmonics of the 500 MHz fundamental RF frequency of the ring, i.e. with 1.5 GHz and 1.75 GHz resp.. Two cavities of each kind will be combined in a module as shown in [1], Fig. 1. For testing purposes, a prep(aration) phase module without the two 1.75 GHz cavities is planned, having a "cold" string as shown in Fig. 1. The denomination of "cold" needs in both cases the explanation, that first the cavities are not subject of the discussion here, whereas the warm end groups outside the module are considered as a natural part of the "cold" string as they experience a strong field coupling with the interior cryogenic parts of the module through the 110 mm diameter beam pipe. Also the warm waveguide loads [3] attached to each of the five waveguides of every cavity are included in the definition and will be discussed here in brief.

WARM END GROUP

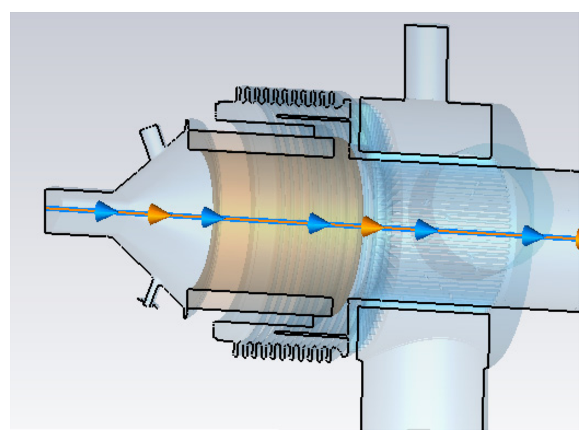

Figure 2: Cross section of the modified Warm End Group

The Warm End Group (WEG, cf. Fig 2) experienced a significant re-design caused by engineering needs, being in its original shape incompatible with proper RF behaviour. This resulted in a now increased below length and diameter, the introduction of an additional (partial) coaxial shielding, modified pumping connections (now three ports for getter pumps plus one used for a corner valve), a RF pickup in the taper section and also a transparent window intended for thermographic observation of the dielectric absorber ring. The material of the latter is now finally chosen as Coorstek SC-35. The beam impedance features a single prominent resonance, by adjustment of the length of the partial coaxial shielding now tuned to a frequency of 354 MHz. Thus it is far away from the 250 MHz beam harmonics, which are prominent

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† hans.glock@helmholtz-berlin.de

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in BESSY II's beam spectrum. Further, it was studied whether the taper sections, which are of complicated shape and thus expensive, could be replaced by hard cross section steps, which also would have saved valuable length of ~ 10 cm. Even though simulations showed a reasonable longitudinal impedance spectrum, this would result in transversal short range wake kicks being not acceptable. Now the WEG is in its final engineering, preparing also the ordering of a set of prototypes.

WARM WAVEGUIDE ABSORBER

Three prototypes of the warm waveguide absorbers (cf. [3]), manufactured by JeffersonLab (JLab), are in house at HZB, mainly for additional studies according cleaning and outgassing processes. Low and high-level RF properties were tested successfully at JLab, showing thermal stability with 1100 W cw incident RF power (at 2.45 GHz) , which exceeds the design value by a factor of 2.5. Under those conditions the hottest spots on the ceramic surface reached 125 °C (cf. Fig. 3). The cooling water flow was adjusted to 0.8 liter/min, which is well below to the onset of water turbulences, found with acoustical measurements at 3.0 liter/min.

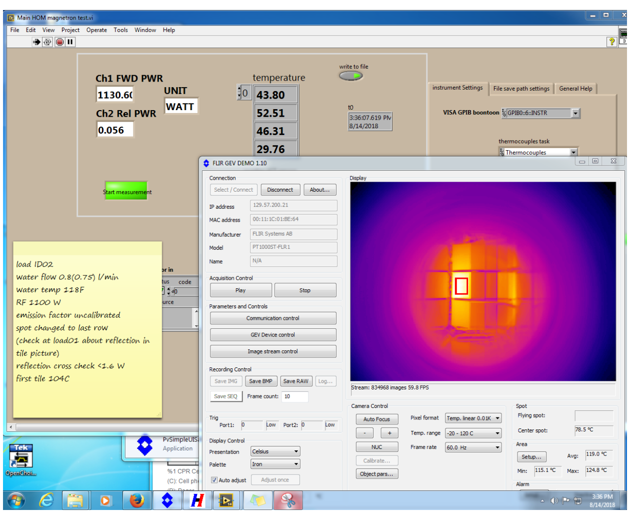
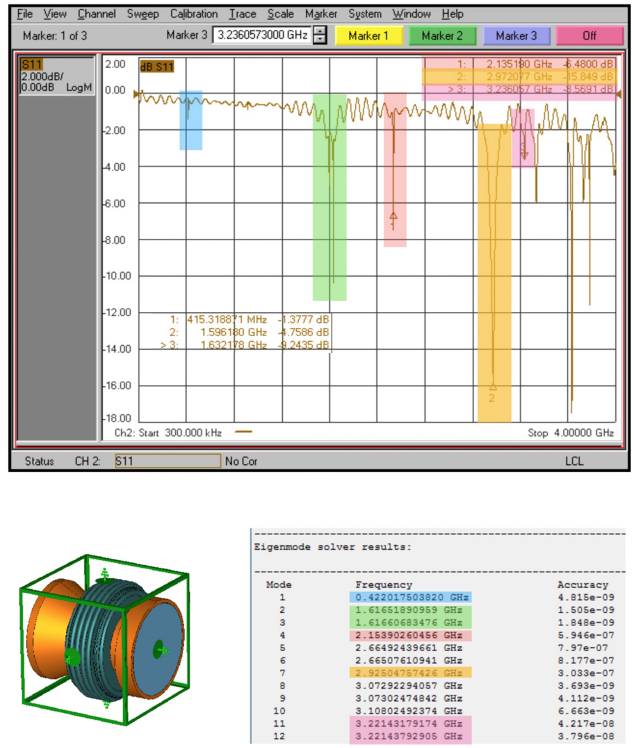


Figure 3: Measurement screenshot of the high-power RF test of the VSR HOM load prototype ID02.

The mounting sequence for the loads was modified in a way that all stainless steel weldings now are done prior to the brazing of the backplate, which then is already equipped with the ceramic tiles. A flange preparation for the use of VATSeal gaskets like it is described in [4] is currently under investigation.

COLLIMATING SHIELDED BELLOW

One full-functional prototype of the Collimating Shielded Bellow (CsB, cf. [1], Fig. 2) is now available at HZB and underwent first RF and cleaning tests. Figure 4 illustrates the good coincidence between network-analyzer measured (S_{11}, using a roughly centred capacitive pick-up antenna in one of the flange-closing end plates) and computed eigenfrequencies. Figure 5 shows the component during first particulate tests which revealed no worrying particulate emissions, even though an additional wet cleaning step in an ultrasonic bath was not applied yet.



Eigenmode solver results:

Mode	Frequency	Accuracy
1	0.422017503820 GHz	4.815e-09
2	1.61651890959 GHz	1.505e-09
3	1.61660683476 GHz	1.848e-09
4	2.15390260456 GHz	5.946e-07
5	2.66492439661 GHz	7.97e-07
6	2.66507610941 GHz	8.177e-07
7	2.92504757426 GHz	3.033e-07
8	3.07292294057 GHz	3.693e-09
9	3.07302474842 GHz	4.112e-09
10	3.10802492374 GHz	6.663e-09
11	3.22143179174 GHz	4.217e-08
12	3.22143792905 GHz	3.796e-08

Figure 4: Measured (above) and simulated (below, together with a sketch of the simulation model) resonances of the CsB prototype at default length; showing good mutual agreement.

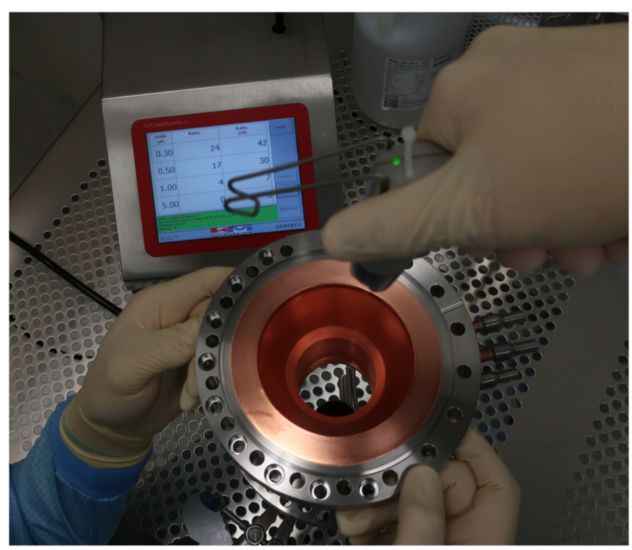


Figure 5: Prototype of the CsB during particulate counting in the clean room, revealing modest emission rates.

Within the upcoming shutdown a combined experiment will be inserted in BESSY II (cf. Fig. 6); the CsB (together with unavoidable taper sections on either side) will be one part of it in order to test thermal, RF and

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vacuum properties of the prototype. The components needed for this are all in house, mounting is in progress.

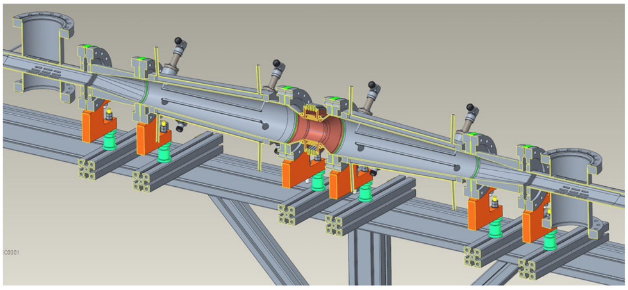

Figure 6: Setup of the CsB beam experiment to be installed at BESSY II during the upcoming shutdown. The CsB will be accompanied by tapers equipped with stripline-like couplers needed to monitor and damp wake power deposited in the area.

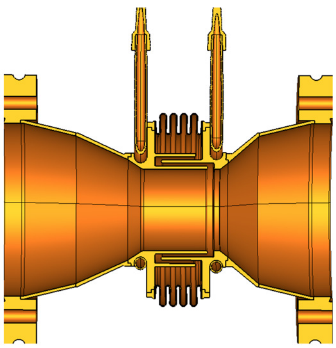

Figure 7: CsB modified with additional welded and copper-coated tapers (PrepCsB) to be mounted in between the two 1.5 GHz cavities used in the preparation phase test module (cf. Fig. 1).

For the preparation phase (cf. Fig. 1) a modified design of the central below is foreseen (PrepCsB, cf. Fig. 7), keeping an inner shape identical to the CsB but featured with two additional welded taper elements. This was estimated as the least complicated (no additional flanges) and shortest (minimal cool-down shrinkage) solution. The wake properties of this setup in between two 1.5 GHz cavities will be cross-checked in upcoming simulations; eigenmode analysis of the individual component showed the expected correspondence to well known modes of the CsB without additional tapers.

MODULE-END BELLOW

The Module-End Bellows (MeB, cf. Fig. 8) are still in a conceptional phase, awaiting detailed engineering. It is foreseen to split them into two parts of slightly different inner diameter (110 mm and 115 mm, both being standard series parts), giving the opportunity to tune them actively by moving the central part (which also will serve as cooling intercept). This will mitigate the risk to hit the 8th beam harmonic at 2.0 GHz with a resonance of this setup typically found in close neighbourhood since defined by the beam pipe's cut-off. Simulation showed a tuning sensitivity of 830 kHz/mm; bellows will allow for a spread of ± 3 mm.

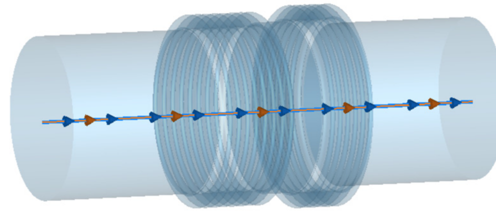

Figure 8: Simulation model of the MeB, featuring two separate segments of slightly different diameters. The straight part in between will be tuneable by an active linear mover and also be used as cooling intercept.

CONCLUSION

The development of the "cold" string components for BESSY-VSR are ongoing, now having first hardware in house and with a first attachment of BESSY II coming in the near future. Recent experiences illustrate the need of simulation cross checks after the detailed engineering of conceptional designs. Those may reveal issues not considered before, though not being sufficient to replace careful experimental validations. Therefore supporting experimental checks are foreseen in each major step of the VSR project, namely e.g. the upcoming beam experiment and the preparation phase test module.

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