ISBN: 978-3-95450-227-1 ISSN: 2673-5490 doi:10.18429/JACoW-IPAC2022-THPOST025

OPERATIONAL EXPERIENCE WITH THE IMPROVED VSR DEMO COLLIMATING SHIELDED BELLOW IN BESSY II

H.-W. Glock†, V. Dürr, F. Glöckner, J. Knobloch[1], M. Ries, A. Velez[2]
Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany
[1]also at University of Siegen, Siegen, Germany
[2]also at Technical University Dortmund, Dortmund, Germany

Abstract

The Collimating Shielded Bellow (CSB) is designed to serve both as a flexible beam pipe connection between two adjacent superconducting cavities as foreseen in VSR DEMO and as a synchrotron light collimator to shield the down-stream cavity from synchrotron radiation. A convoluted inner RF shield was applied to prevent fundamental mode heating of the stainless-steel-made bellow in the cryogenic environment, making the such captured inner volume very difficult to access for inspection and cleaning. A first version of the device (CSB1) was successfully tested as part of the beam pipe of the synchrotron light source BESSY II under regular operation for more than a year. It suffered from an unfavourable long outgassing commissioning. Therefore a detachable design, allowing for rigorous inner surface preparation and cleaning, was built and recently installed in BESSY II. CSB version 2 (CSB2) design and experimental outcomes are described in the paper. First results indicated a significantly improved vacuum commissioning performance, which was confirmed later on.

CSB FOR THE VSR DEMO MODULE

VSR Demo

VSR Demo, recently under construction at HZB, aims to demonstrate the technical feasibility of a beam-ready cryo-module [1] featuring two 1.5 GHz superconducting RF (SRF) cavities designed for strong bunch length modulation in the storage ring of the 3rd generation, 300 mA synchrotron light source BESSY II. This module will be used as a demonstrator for a later 4-cavity BESSY-VSR-module (Variable bunch length Storage Ring) [2], designed with two additional 1.75 GHz SRF cavities, which will allow to simultaneously offer long and short bunches in a fill pattern.

CSB Purpose, Development and Testing

In [3] the purpose and design of CSB1 as a flexible cryo-compatible beampipe connection between two SRF cavities in VSR, acting also as an actively cooled synchrotron light collimator, was explained in detail. In [4] the testing setup was described, which was used both to test CSB1 (Aug. '19 to Dec. 2020) and later CSB2 (Jan. to May 2022). CSB1 tests were successful in general, but the initial vacuum conditioning took an unsatisfactory long time of about 80 days. Furthermore significant discolourations were found inside the bellow after destructive dismantling, as described in [5]. Both drawbacks were understood as a consequence of the very limited access to the captured volume between the coaxial shielding labyrinth and the bellow. Therefore a new design was developed, which incorporates a central flange, allowing to separate the device in two parts and to prepare, clean and inspect this inner volume (cf. Fig. 1). In order to be able to mount the screws for this central flange the downstream taper needed a length extension of 30 mm. Otherwise CSB2 fully resembles the inner design of CSB1, which in particular preserved the RF properties of the few localized electromagnetic eigenmodes (cf. [3]).

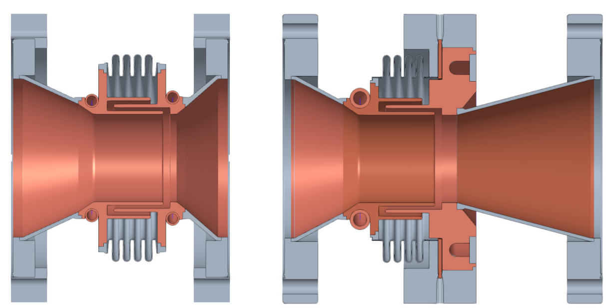

Figure 1: Cross sections of CSB1 (left) and CSB2 (right). Copper parts in red, stainless steel in grey, outer taper parts copper coated.

Manufacturing of CSB2 was delayed by a leaking brazing of the stainless-steel ring of the central flange to the new designed core copper part. It needed rebuilding of that part with careful adjustment of the brazing parameters like gap width, brazing material and temperature to resolve this issue. Therefore it was not possible to install CSB2 as originally planed during the 2021 summer shutdown of BESSY II, but only half a year later. CSB2 experienced wet ultrasound cleaning, 120 °C drying, clean room closing with particulate release control before its mounting in BESSY II in Dec' 21, using a temporary local cleanroom.

* work supported by grants of the Helmholtz Association
† hans.glock@helmholtz-berlin.de

ISBN: 978-3-95450-227-1 ISSN: 2673-5490 doi:10.18429/JACoW-IPAC2022-THPOST025

CSB2 OPERATIONAL EXPERIENCE

With beginning of January 2022 CSB2 came into operation in BESSY II. As indicated above the experiment re-used the existing experimental environment, i.e. the taper, pumping and sensor setups. Also the remote-controlled linear mover, which allows to adjust the bellow length, was re-installed.

It was immediately possible to raise the machine current to the nominal value of 300 mA, whilst CSB1 needed (together with some other installations new in BESSY II at that time) reduced current settings during the early conditioning. Vacuum conditioning was much faster than that of CSB1 and reached the lower measurement limit after 10 calendar days (with some machine down time for other commissioning reasons, cf. Fig. 2). About 20 minor and two strong pressure spike events were counted in that time, which is a much lower frequency than seen with CSB1.

As the first of the special operation modes of BESSY II single bunch operation with a current of 20 mA was tested. There again a very fast conditioning, visible only for 20 minutes (cf. Fig. 3), was observed.

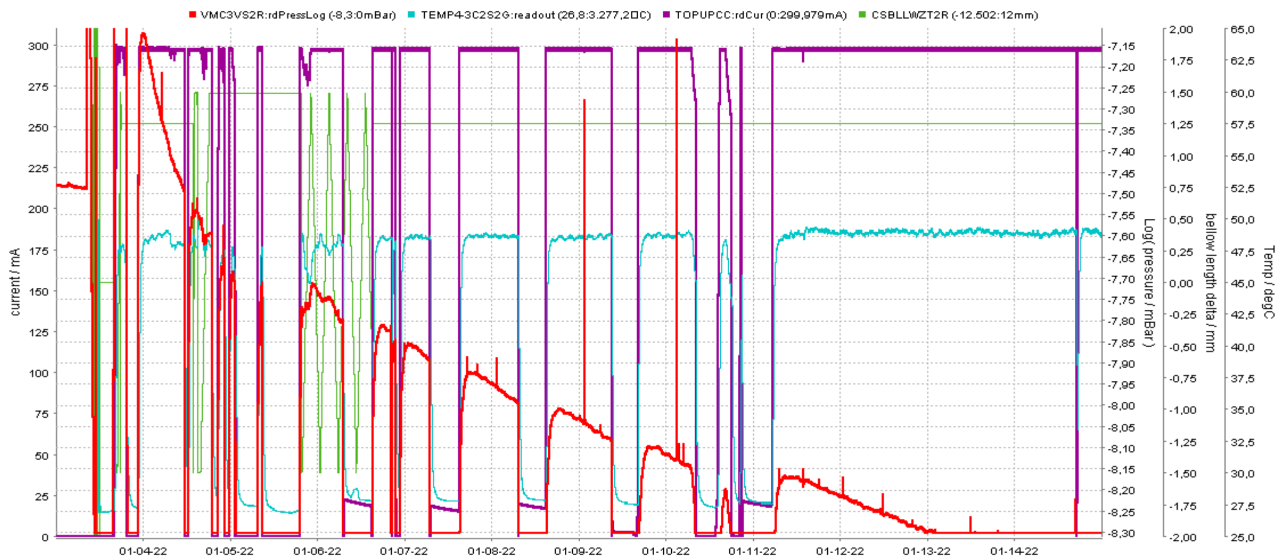

Figure 2: BESSY II's data archiver readout for the first 12 calendar days of CSB2 pressure (red) and taper temperature (light blue). BESSY II was operated from the beginning with nominal 300 mA machine current (magenta), whilst experiencing some interrupts for other reasons. Initial bellow length (green) variations triggered no pressure events.

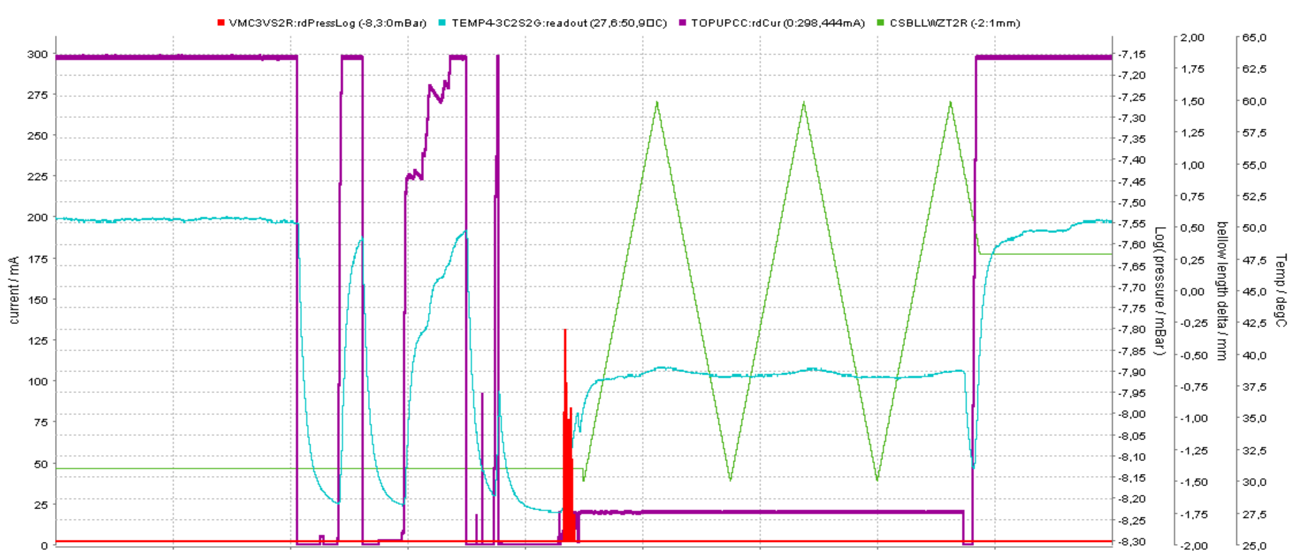

Figure 3: First single bunch operation of CSB2, starting at 24th Jan', 17:00 with 20 mA beam current. Vacuum conditioning (red, all colours like Fig. 2) was completed after 20 minutes. Also there were no visible pressure reactions on length variations (whilst a length-correlated slight temperature change was monitored).

ISBN: 978-3-95450-227-1 ISSN: 2673-5490 doi:10.18429/JACoW-IPAC2022-THPOST025

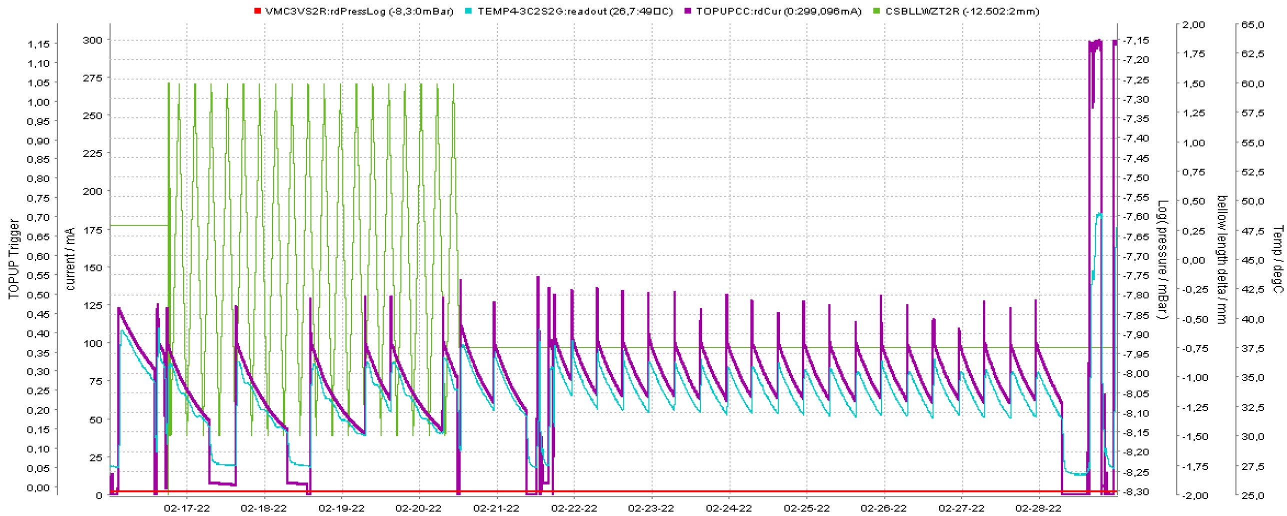

Figure 4: Low-Alpha operation of BESSY II, i.e. a particular bunch compression used in decay-mode, tested up to 100 mA and together with an extended phase of bellow length variations. Whilst a thermal reaction in clear correlation to the current was observed, no single vacuum event was seen (all colours like Fig. 2).

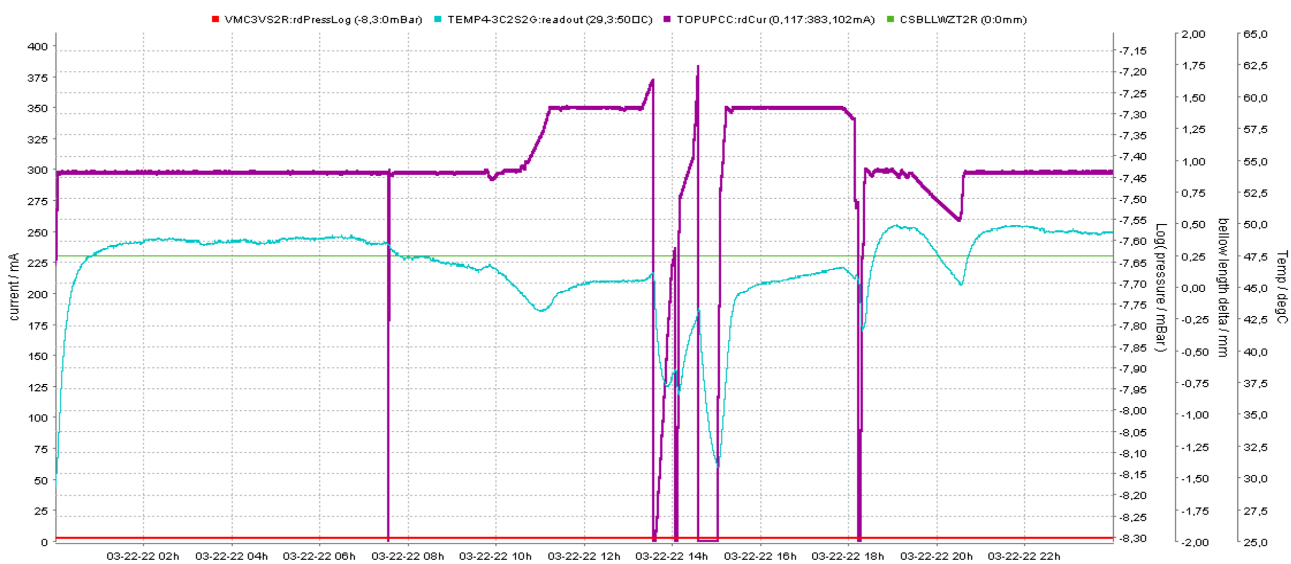

Figure 5: BESSY II tested with 350 mA (all colours like Fig. 2, extended current scale). Interestingly the additionally filled buckets led to a different current spectrum with lower ohmic losses, thus temperature.

From 7th to 13th Feb BESSY II was operated with 15 mA single bunch, followed by one day with 32 mA distributed to four equally spaced bunches (so called "few-bunch-operation") without any observable pressure reaction at CSB2. Same holds for the 12 days period starting at 16th Feb of low-alpha operation, which also included 4 days of length cycling (cf. Fig. 4). A rare experiment, raising BESSY II's current to 350 mA, was conducted at 22nd March (cf. Fig. 5). Individual bunch charges were kept, but about half of the regular pause of 100 buckets were additionally filled. This interestingly lowered the taper temperature, which can be explained by the shift of spectral beam current components away from RF resonances of the setup. Again no pressure reactions were seen.

CONCLUSION

The maturity of the CSB's RF, mechanical and thermal design already was demonstrated during the long operation of CSB1. The introduction of the separating flange in CSB2 removed the difficulty to appropriately clean and inspect the inner surfaces, resulting in CSB2's much better vacuum performance without revealing any further operational issues. The last still outstanding validation step, i.e. operation under cryogenic conditions, will need the completion of the VSR Demo module.

ISBN: 978-3-95450-227-1 ISSN: 2673-5490 doi:10.18429/JACoW-IPAC2022-THPOST025

REFERENCES

[1] F. Glöckner *et al.*, "The VSR Demo Module Design – a Spaceframe-based Module for Cavities with Warm Waveguide HOM Absorbers", *in Proc. of 20th Int. Conf. on RF Superconductivity (SRF2021)*, East Lansing, MI, USA, Jun.-Jul. 2021, pp. 233-236. doi:10.18429/JACoW-SRF2021-MOPTEV013

[2] A. Jankowiak, J. Knobloch *et al.*, "Technical Design Study BESSY VSR", Helmholtz-Zentrum Berlin, 2015. doi:10.5442/R0001

[3] H.-W. Glock *et al.*, "Design of the Beamline Elements in the BESSY VSR Cold String", in Proc. 9th Int. Particle Accelerator Conf. (IPAC'18), Vancouver, Canada, May 2018, pp. 4123-4126. doi:10.18429/JACoW-IPAC2018-THPMF033

[4] H.-W. Glock *et al.*, "Progress of the BESSY VSR Cold String Development and Testing", in *Proc. 10th Int. Particle Accelerator Conf. (IPAC'19)*, Melbourne, Australia, May 2019, pp. 1434-1436. doi:10.18429/JACoW-IPAC2019-TUPGW019

[5] N. Wunderer *et al.*, "VSR Demo Cold String: Recent Developments and Manufacturing Status", in *Proc. of 20th Int. Conf. on RF Superconductivity (SRF2021)*, East Lansing, MI, USA, Jun.-Jul. 2021, pp. 647-651. doi:10.18429/JACoW-SRF2021-WEPTEV008