OPTIMIZATION AND EXPERIMENTAL CHARACTERIZATION OF A BROADBAND CIRCULAR WAVEGUIDE TO COAXIAL TRANSITION

E.Weihreter, S. Küchler, BESSY, Berlin, Germany
Y.C.Tsai, K.R.Chu, NTHU and SRRC, Hsinchu, Taiwan

Abstract

Broadband coupling of higher order cavity modes to an external load is one possibility to suppress multibunch instabilities in electron storage rings. A simple waveguide to coaxial transition has been designed and a full size prototype was built, which features a double ridged waveguide with circular cross section. Low power measurements of the broadband transmission characteristics are presented and compared with a numerical simulation including details of the mechanical layout.

1 INTRODUCTION

Damping of higher order modes (HOMs) in the rf-cavities is desirable for 3rd generation synchrotron radiation sources to avoid multibuch instabilities. Such beam oscillations can lead to potential degradation of the photon beam brilliance the essential figure of merrit of a synchrotron radiation source.

For BESSYII, a 3rd generation source actually under commissioning, there are plans to replace the DORIS-type 500 MHz rf-cavities in a second phase by a new cavity design featuring three circular waveguides for HOM damping. Measurements on a low power 'pill box'- type model cavity have shown promising results [1] , and an outline design of a broadband circular waveguide to coaxial transition (CWCT) including a ceramic vacuum window has given hope to avoid the use of rf-absorbing materials inside the cavity vacuum structure.

The basic design goals of an adequate CWCT have been discussed in [2] and [3], here we present a refined geometrical design with reduced diameter and length to reduce cost and ease the installation in a narrow accelerator tunnel.

2 SIMULATION RESULTS

Figure 1 shows the geometrical outline of the optimized CWCT with a tapered circular double-ridged waveguide of constant cut-off frequency f=710 MHz (a) and a transformer section (b) including a 7/8" coaxial line. Reflection parameters |S11| calculated with the HFSS programm [4] are presented in Fig. 2 for both subsections and for the combined structure. For the numerical optimization the waveguide ridges were modeled with sharp corners for simplicity. The prototype CWCT, however, was built with rounded corners of 2mm

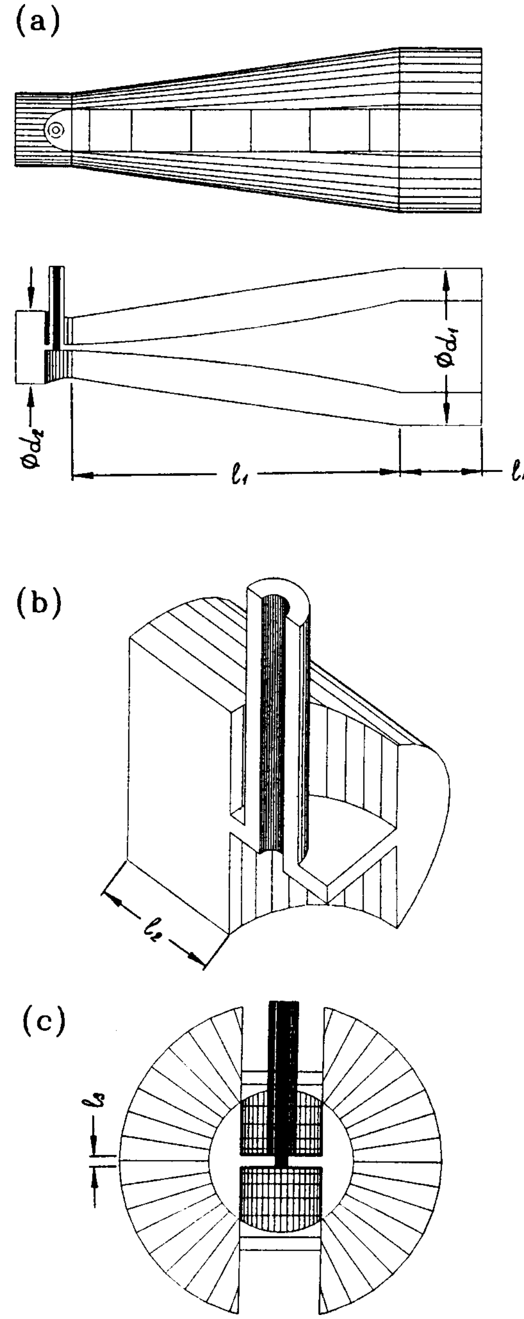

Figure 1: Geometrical structure of the circular waveguide to coaxial transition, l_1= 400mm , l_2= 35mm, l_3= 7mm, l_4= 100mm, d_1= 200mm, d_2= 90mm.

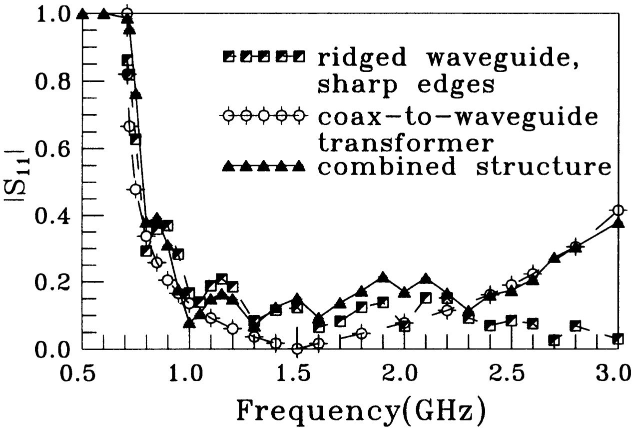

Figure 2: Reflection coefficient |S11| of the ridged circular waveguide, the coaxial transformer and the combined structure from HFSS calculations.

radius to reduce the risk of sparking, particularly at the edges of the ridge, where the highest electric fields are expected. To estimate the effect of rounded corners on the frequency characteristic we have approximated the 2mm radius by an increasing number of straight segments in the numerical model. As indicated in Fig. 3 rounding the ridge edges slightly increases the cut-off frequency but reduces |S11| for frequencies above 1 GHz beneficially.

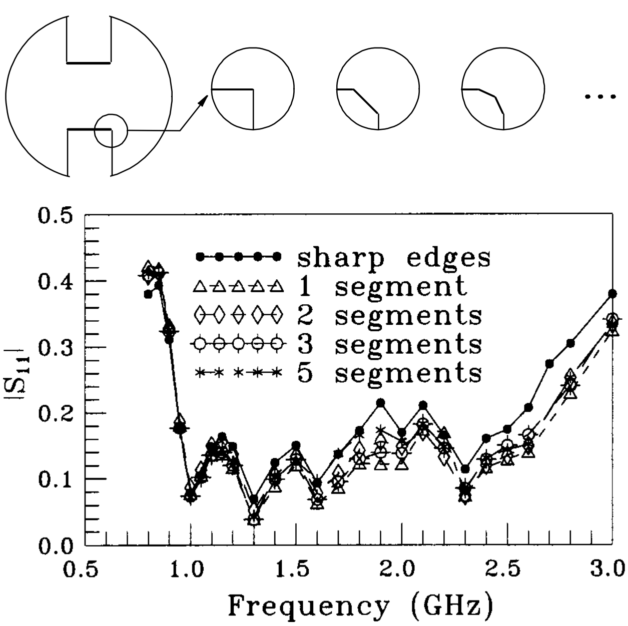

Figure 3: Top - Approximating round edges by straight segments. Bottom - Influence of rounding the edges of the waveguide.

3 MEASUREMENTS

A full scale prototype CWCT has been manufactured from aluminium which consists of two half-shells as shown in Fig. 4.

To determine the frequency characteristics, the CWCT was connected to a Hewlett-Packard model HP 8753D network analyser, using a commercially available broadband 7/8“ coaxial ceramic vacuum window designed by the DAΦNE group in Frascati, and a high

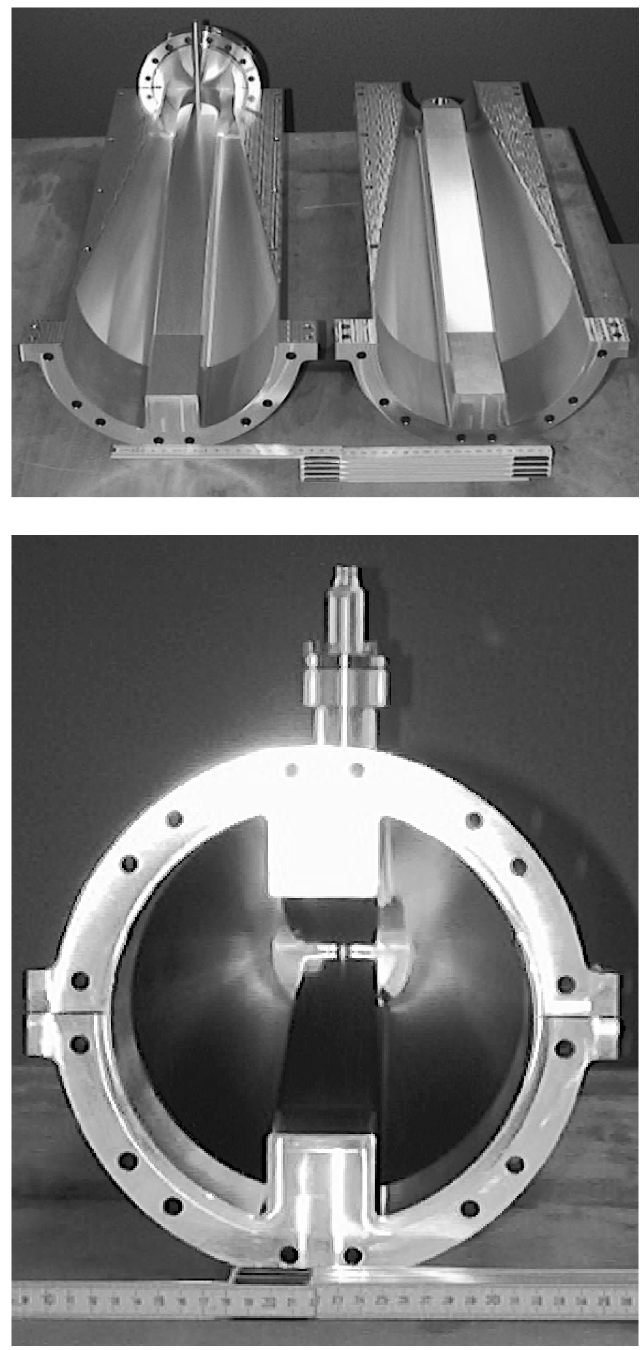

Figure 4: Full scale prototype of the circular waveguide to coaxial transition made from aluminium.

quality 7/8“ to N coaxial transition ($S11 \leq 0.03$ for $0 < f < 3$ Ghz). Figure 5 gives a sketch of the measurement setup. Reflections from the end of the CWCT can be ‘blanked out’ in a time-gated operation mode of the analyser. This

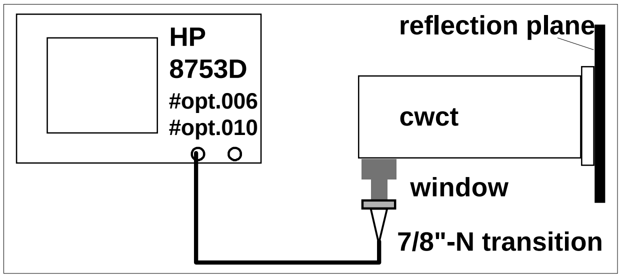

Figure 5: Setup for reflection measurements.

gating technique also allows to measure |S11| of the CWCT alone, separating the contributions from the vacuum window. Figure 6 shows a numerical simulation for the prototype CWCT geometry, where the coaxial vacuum window has not been included, and the reflection measurements for the CWCT - structure as well as for the complete setup including the vacuum window. The measurements are in reasonable agreement with the simulations.

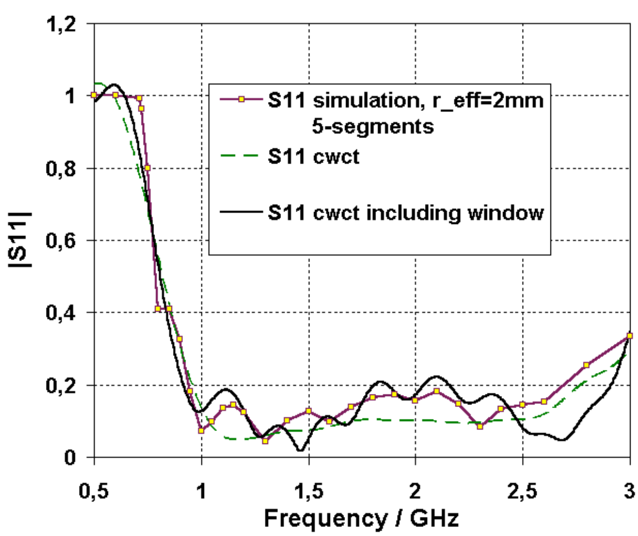

Figure 6: Comparison of a numerical simulation and |S11| measurements of the prototype CWCT.

For frequencies above 1 GHz the coaxial window contributes typically 50% to the total |S11|, which leaves some room for further optimisation. Below the waveguide cut-off frequency (710 MHz) the measurements deviate significantly from the simulations, giving even unphysical |S11| values larger than 1. There is experimental evidence that this can be attributed to the gating operation mode of the network analyzer.

4 CONCLUSION

A detailed design for a broadband circular waveguide to coaxial transition has been worked out by numerical simulation and a full scale aluminium prototype was built. Reflection measurements are in reasonable agreement with the calculations demonstrating the feasibility of a CWCT. In the frequency range from about 830 MHz to 3 GHz the maximum reflection of the CWCT is about 30%, which opens the perspective to use circular waveguides with standard 50 Ω loads outside the vacuum for HOM-damping.

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