Results of the Joint Mode-Stability Experiment

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Working Group 5: RF Modeling
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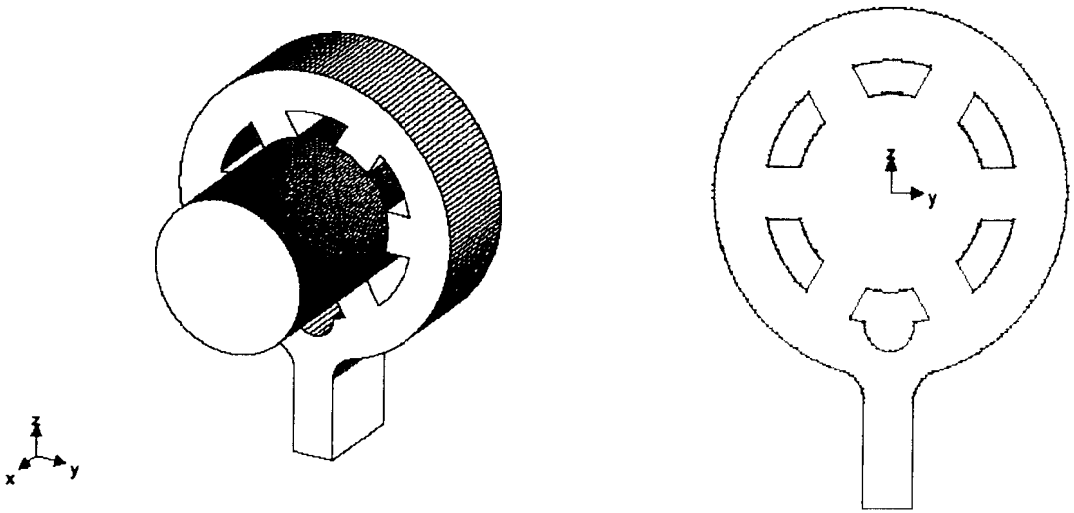
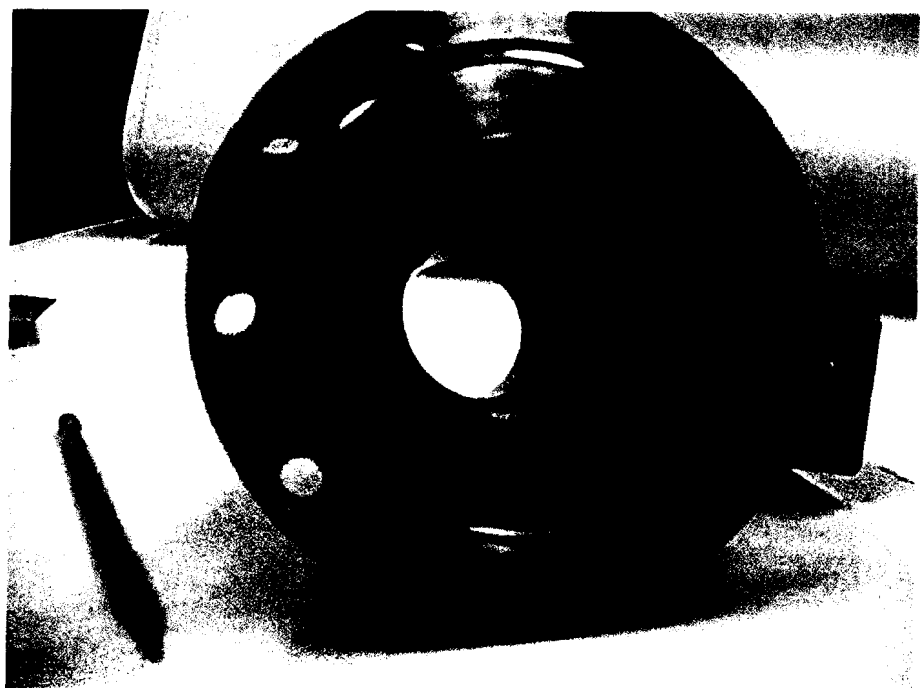
Purpose: Experiments were done with a 55m WC475 (4.75" diam) highly overmoded delay line assembled with "choke" flanges in the KEK ATF injector tunnel to gain experience with the transmission of power in the TE_{12} mode as well as the TE_{01} mode. In particular our goals were

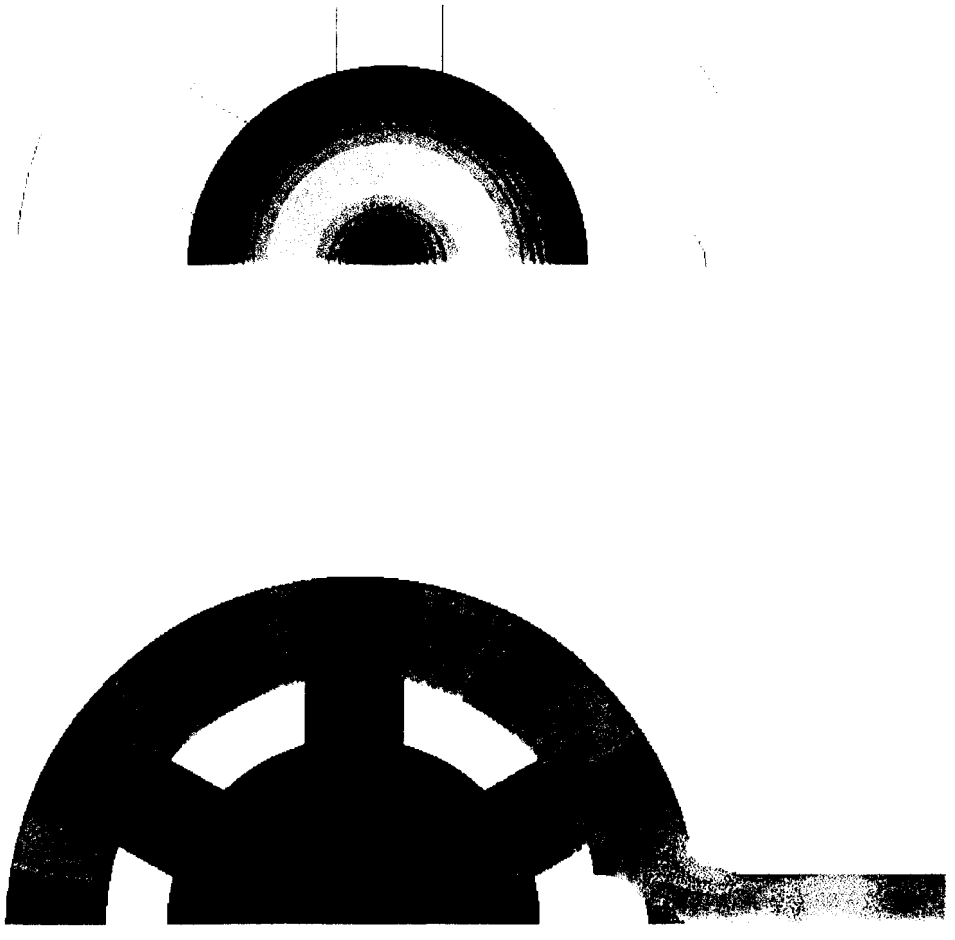
- to demonstrate our ability to launch modes purely w/ launchers
- to measure transmission loss
- to analyze mode purity after transmission and excitations of parasitic modes.
- to check for rotation/circular polarization of TE_{12} after transmission (coupling to cross polarization)

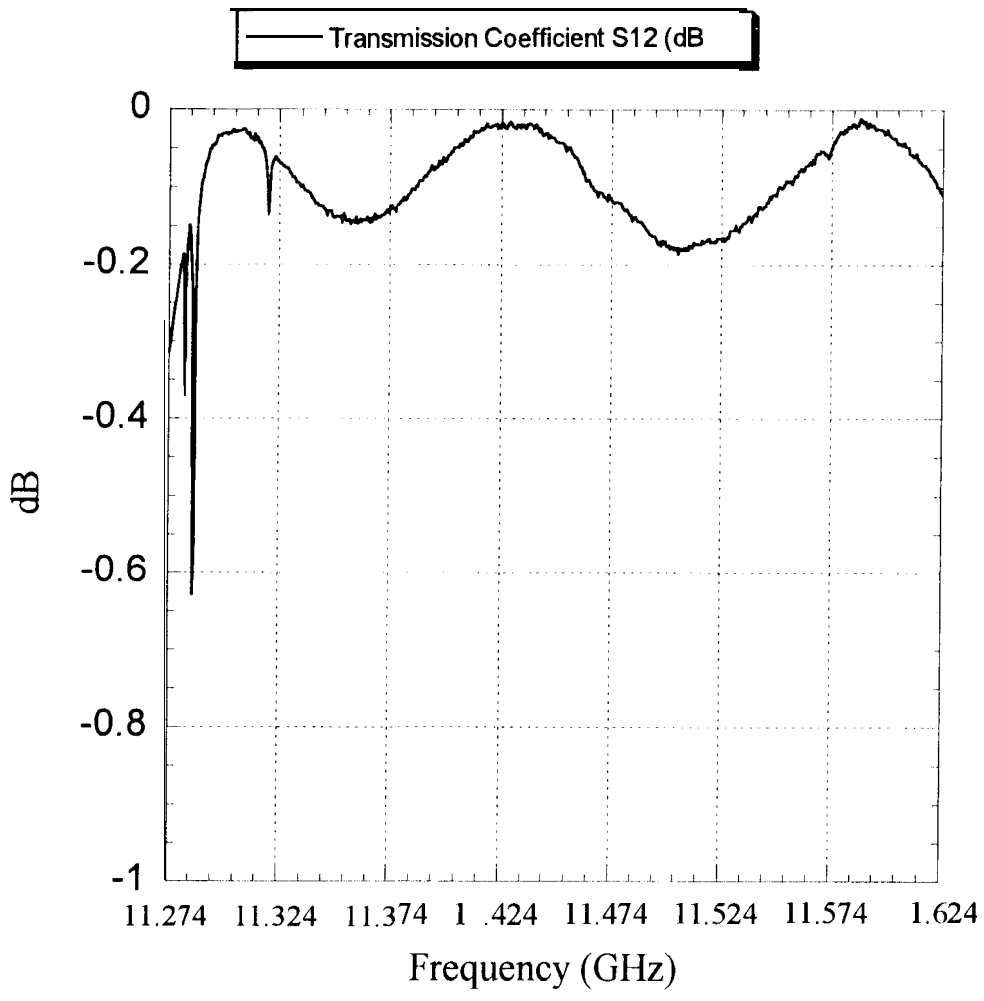




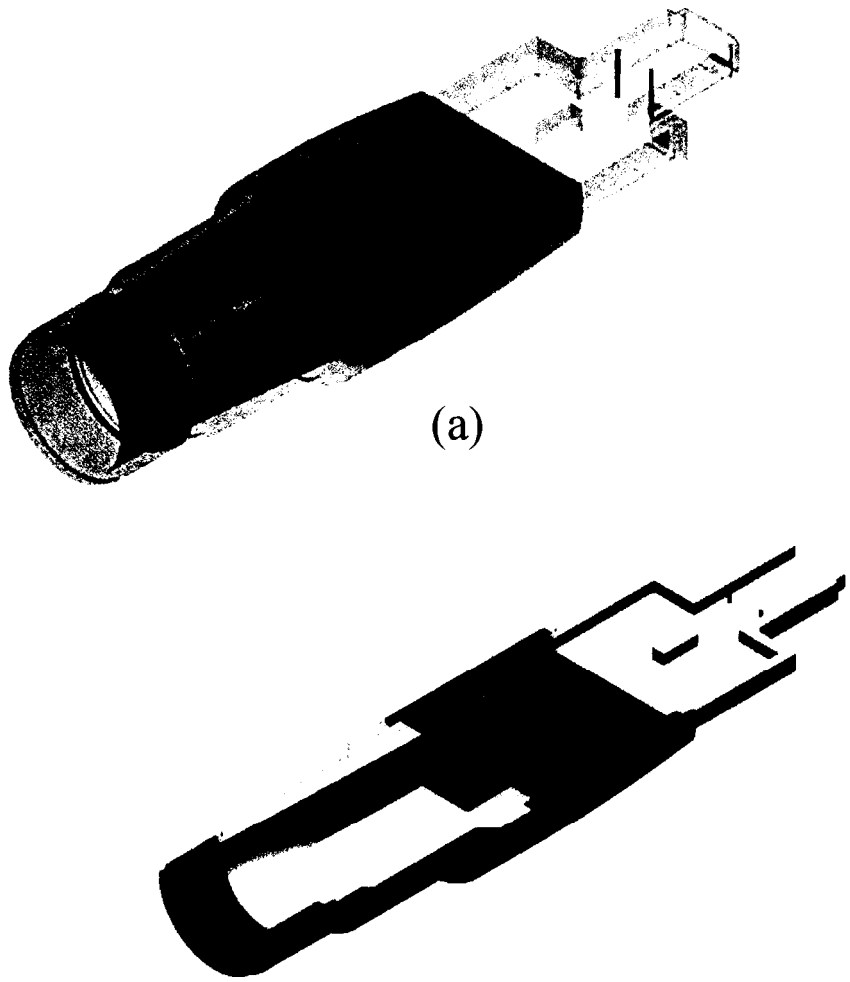
The Wrap-Around Mode Converter. The physical model shown in the picture does not have the back wall shorting plate, this is done for illustration purposes only.

HFSS simulation results for the wrap around mode converter. The color shades represents the magnitude of the electrical field. (a) is a cut plane through the slots, (b) is a cut plane in the circular guide 2.5 cm away from the slots.

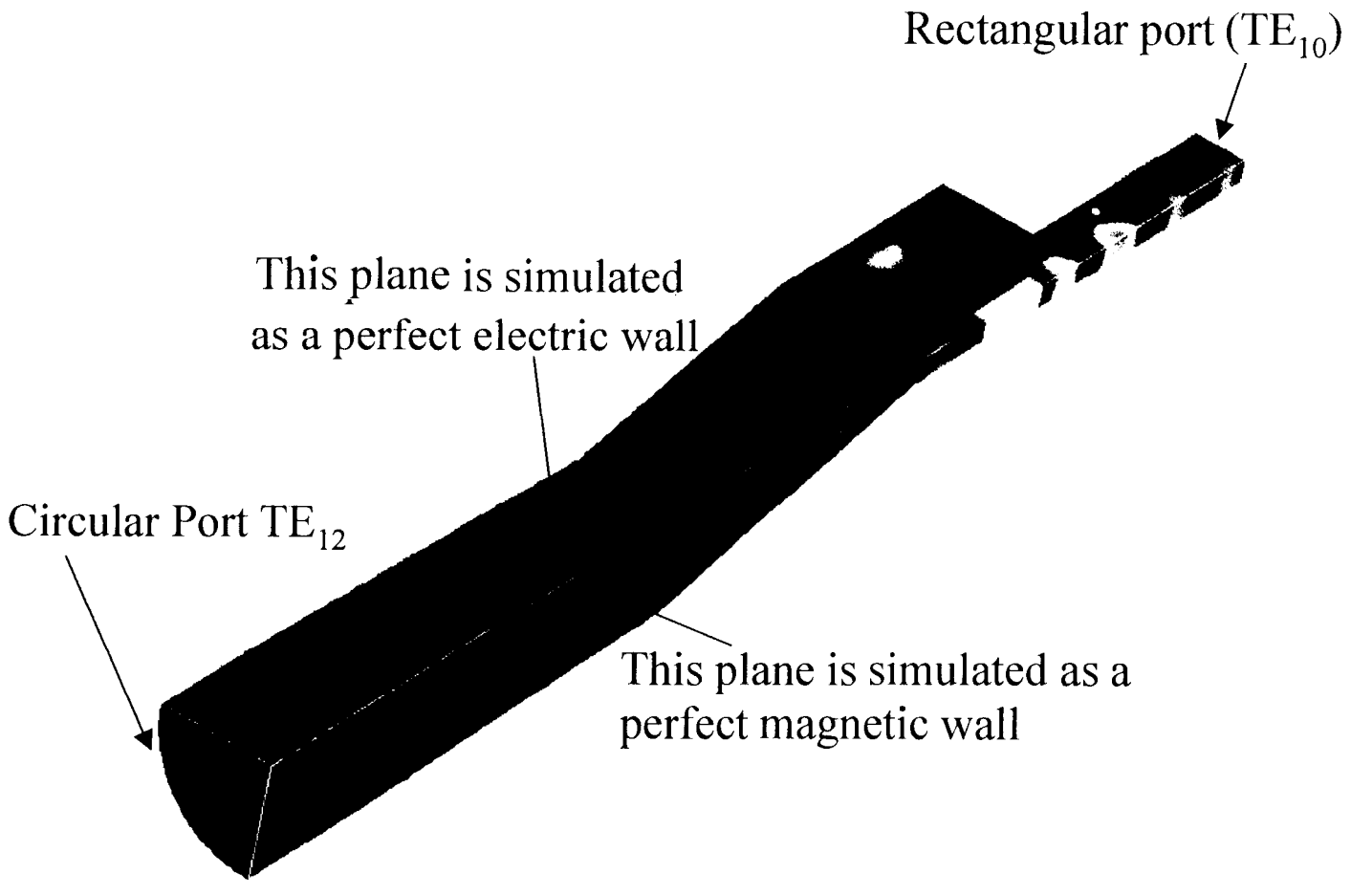




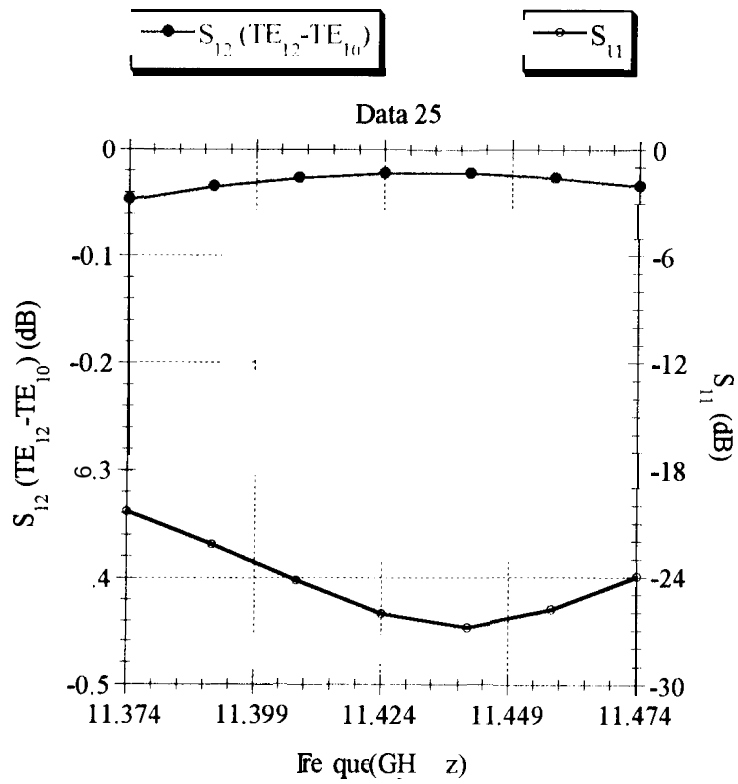
Measured Transmission coefficient for two wrap-around mode converters back to back. The device is optimized at 11.424 GHz.



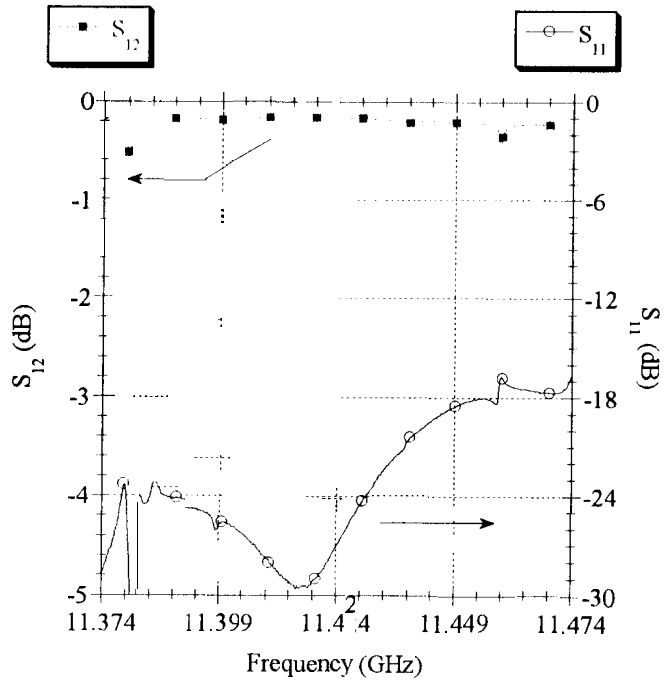
(a)TheCircular-to-Rectangular-TapersTE_{12}Mode┐ʍnsdu<=ɐɹ: ●(b) A cut away view of the structure .



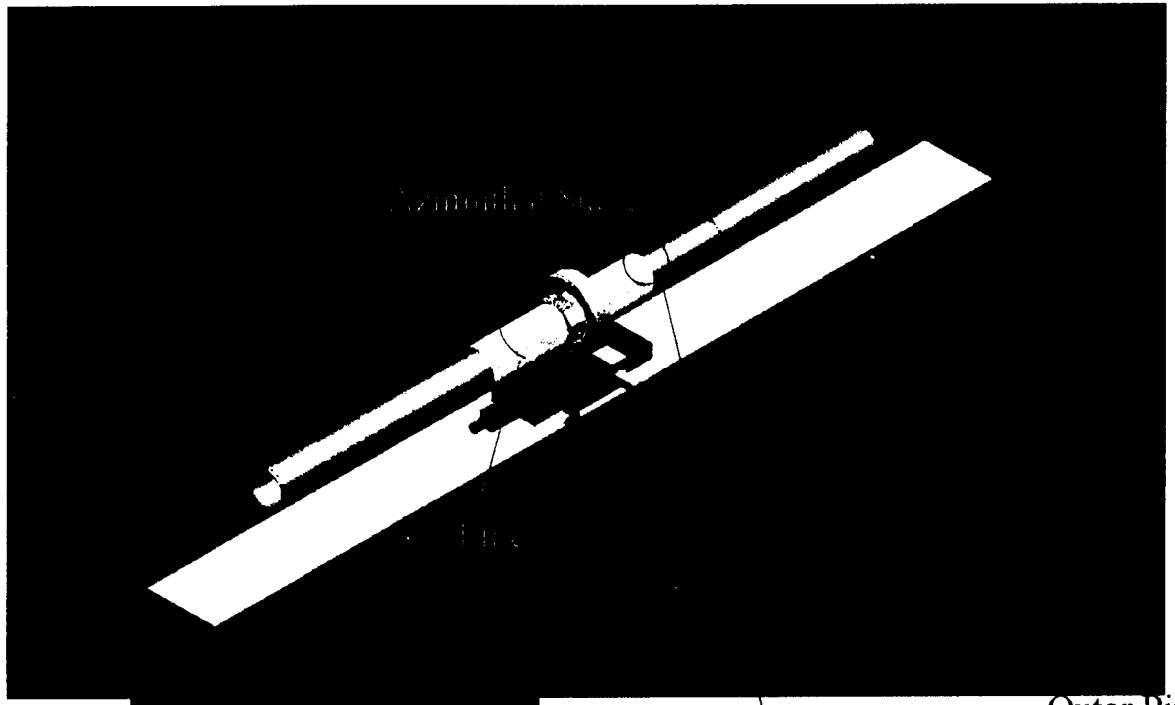
Simulated electric field distribution inside the TE_{12} mode transducer .
The colors represent the electric field strength .

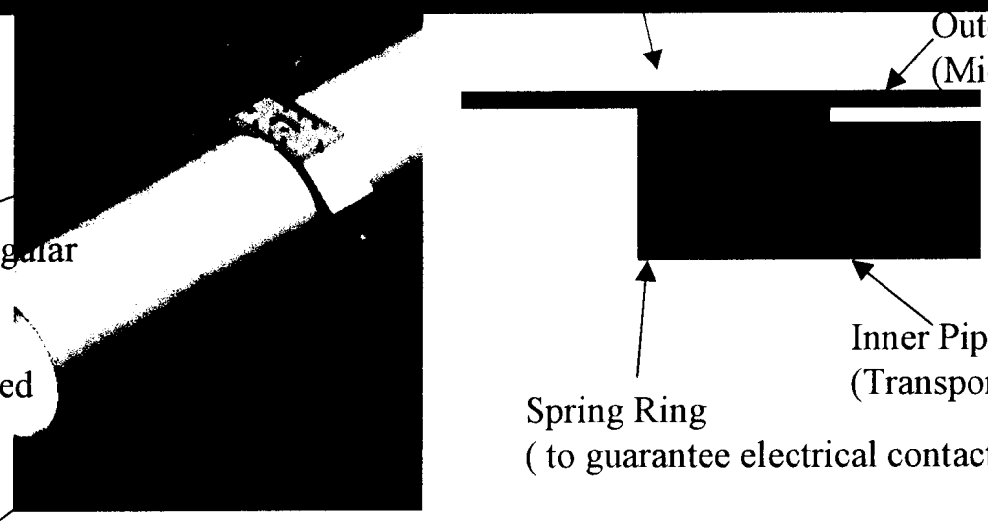


Simulated performance of the TE_{10} (rectangular) to TE_{12} (circular) mode converter. Simulations are done using HP-HFSS.

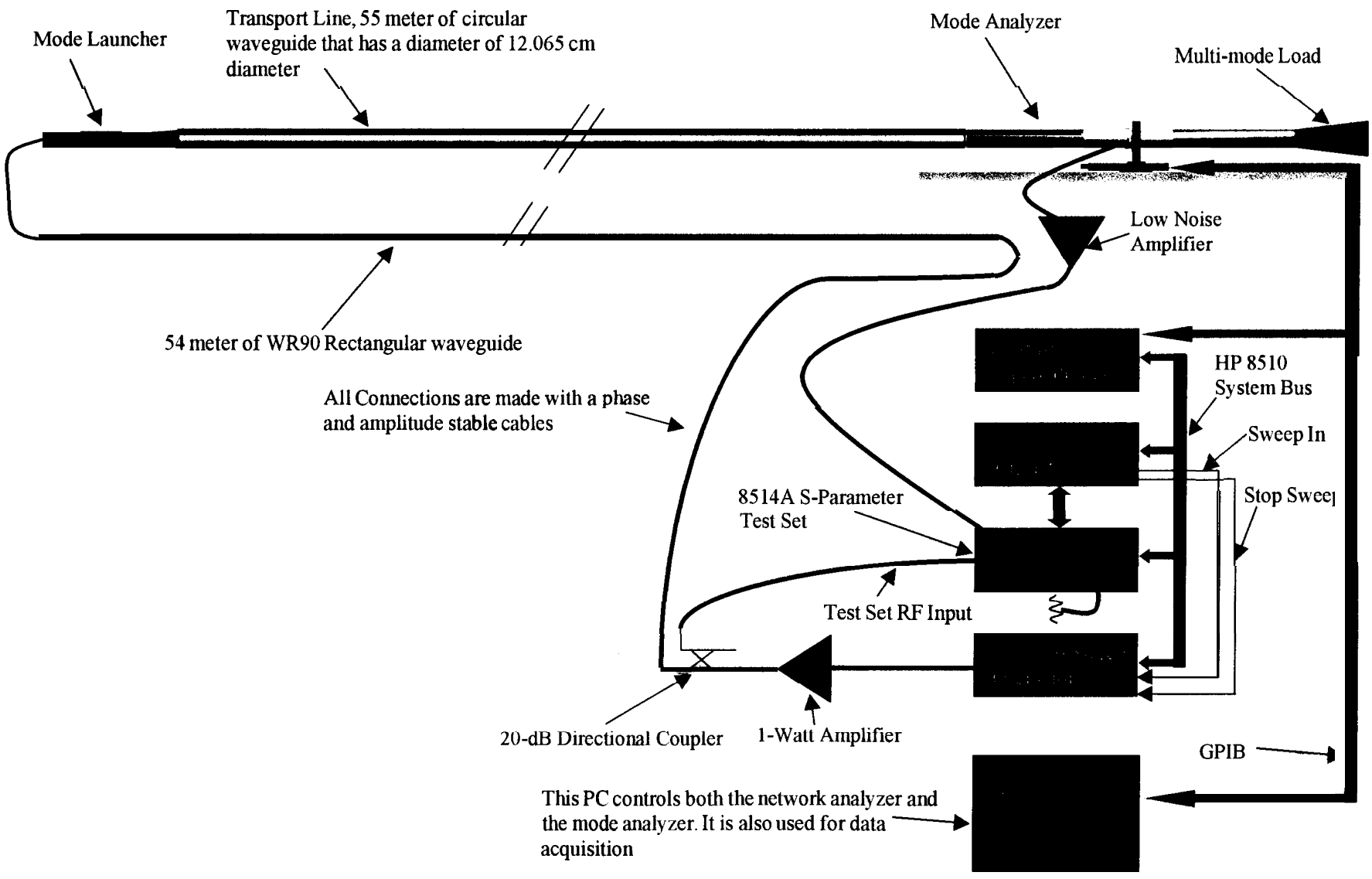


Measured frequency response of two TE_{12} mode tranceducers connected back to back.

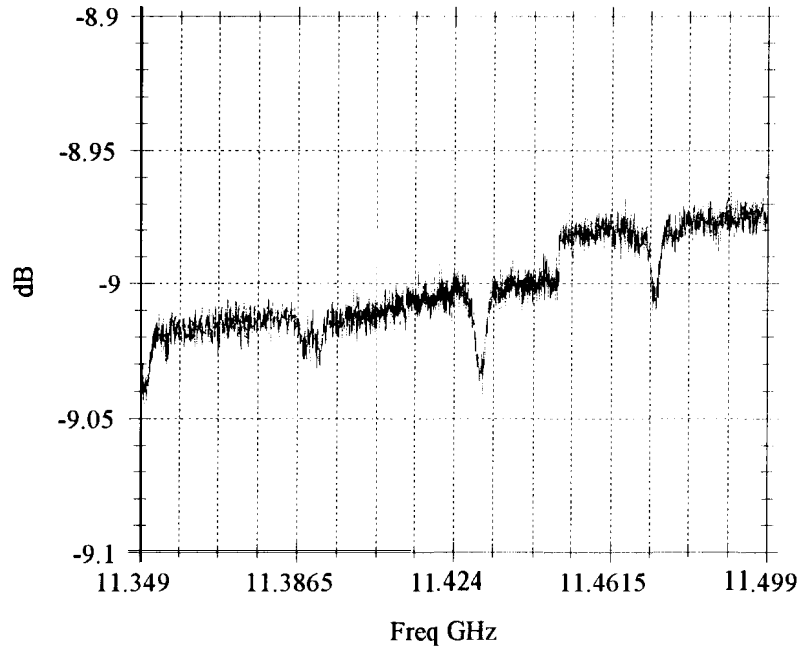




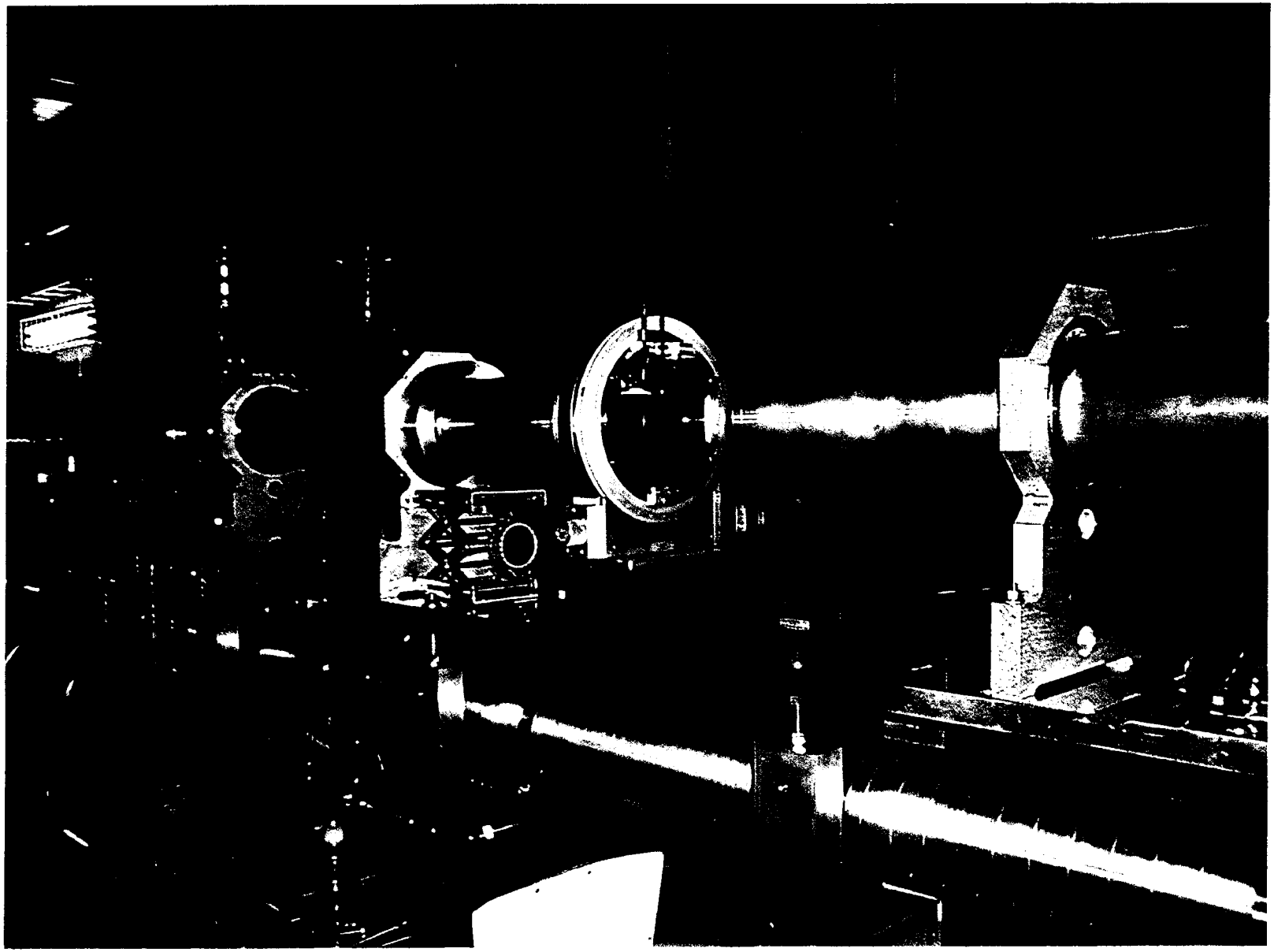
The Mode Analyzer



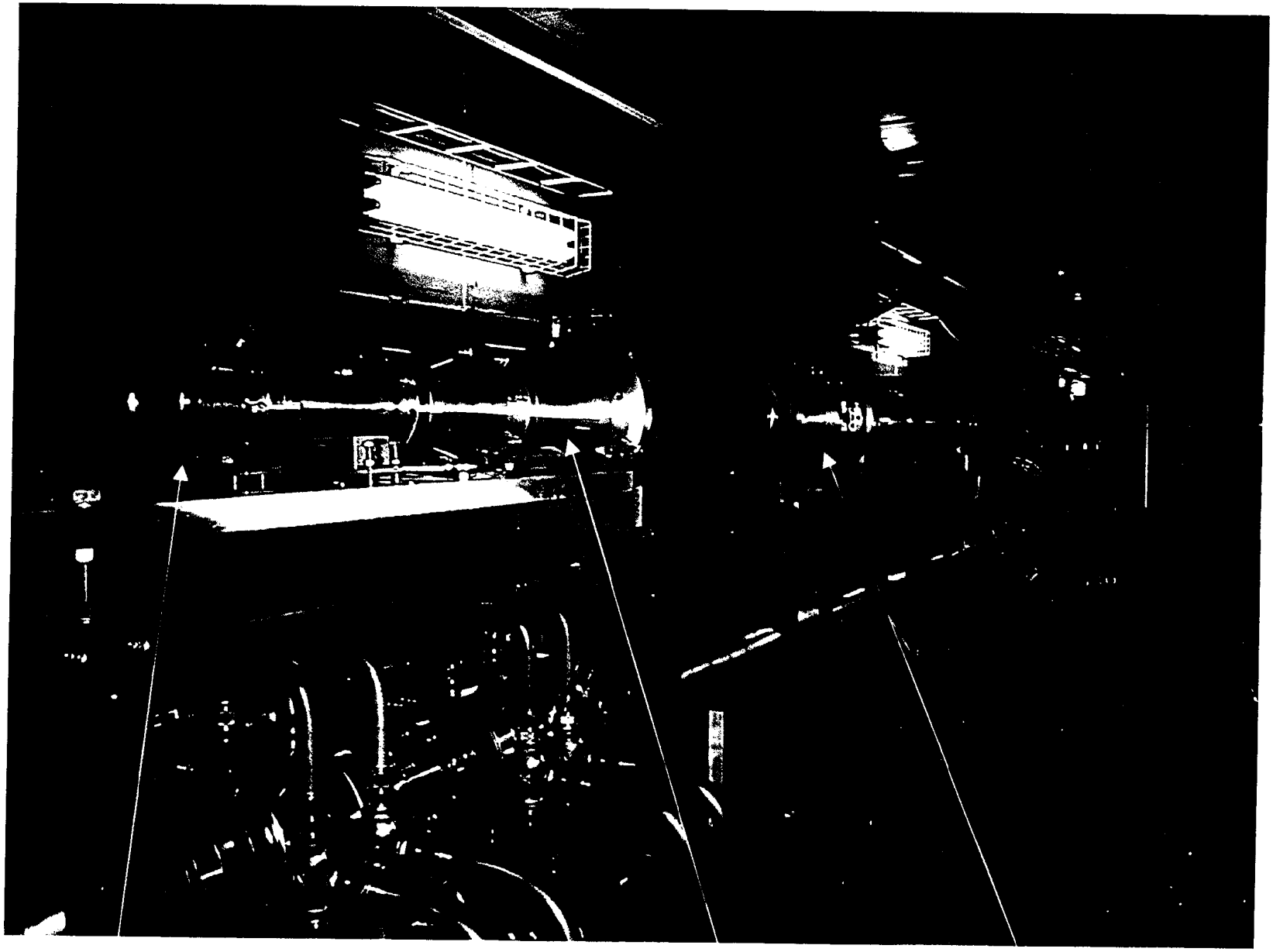
Typical Measurement Setup



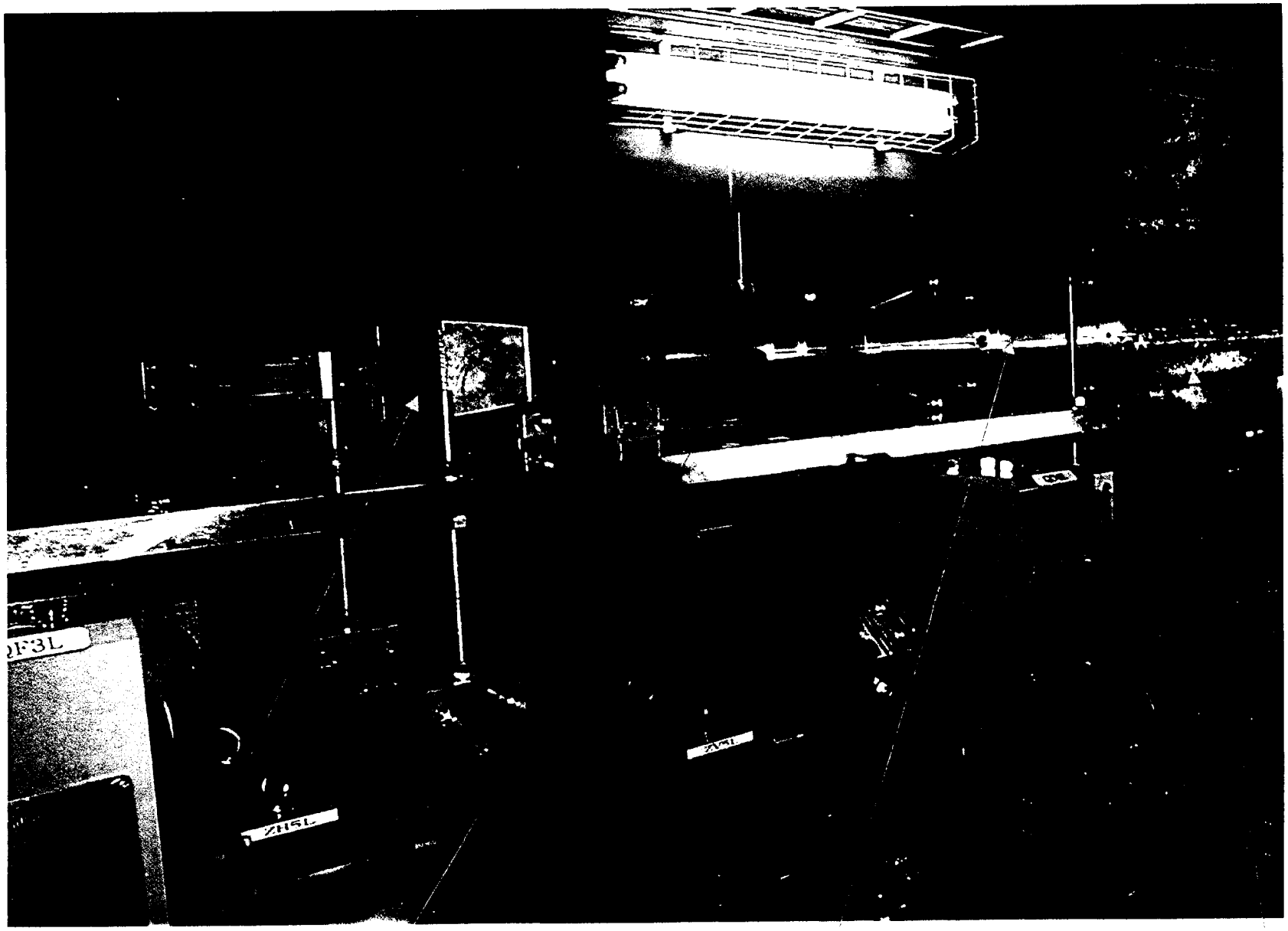
Rectangular waveguide calibration measurements



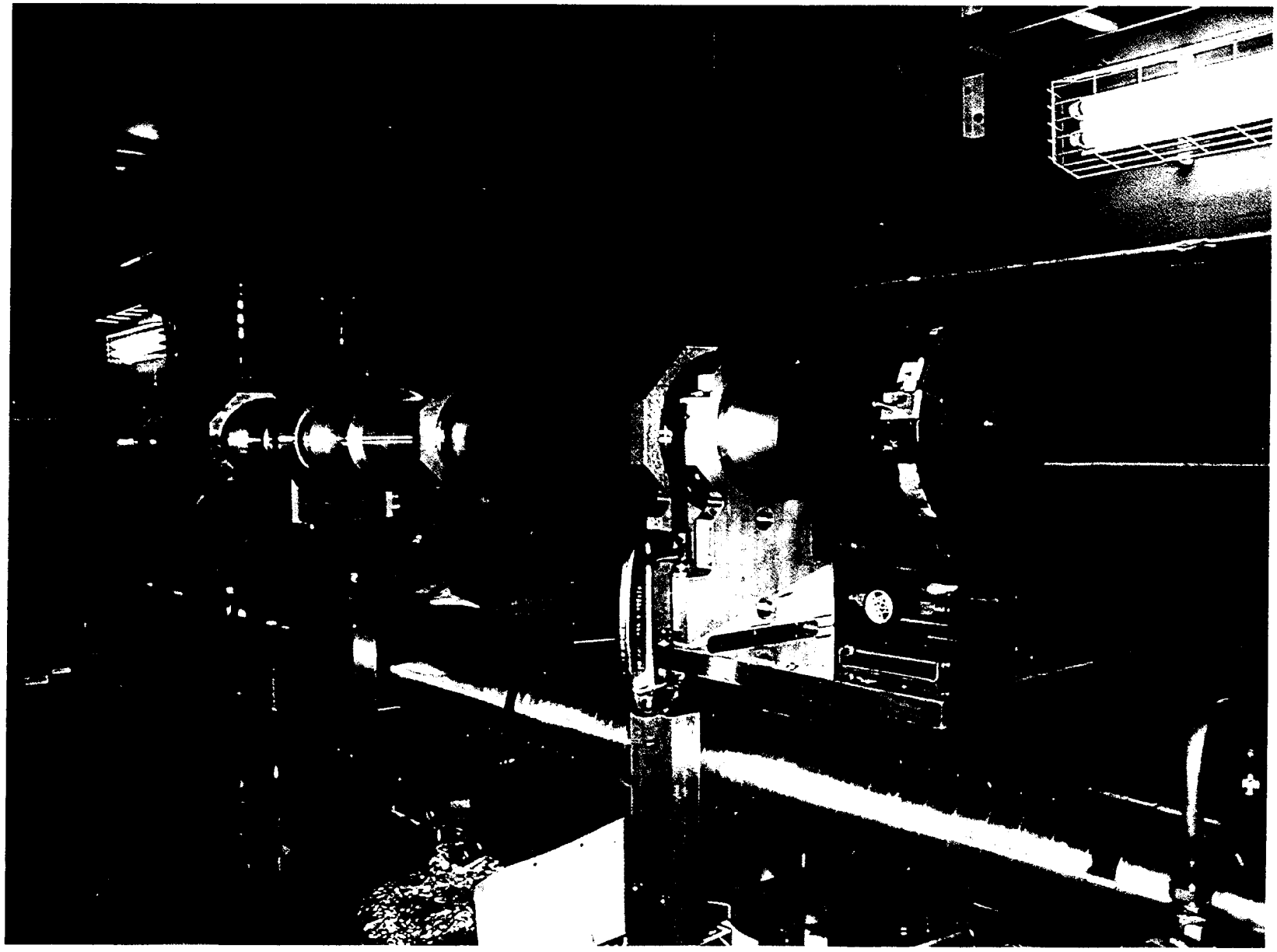
The Mode analyzer being Aligned



The Wrap-Around Mode Converter, The Arc-Taper, and the Mode Analyzer

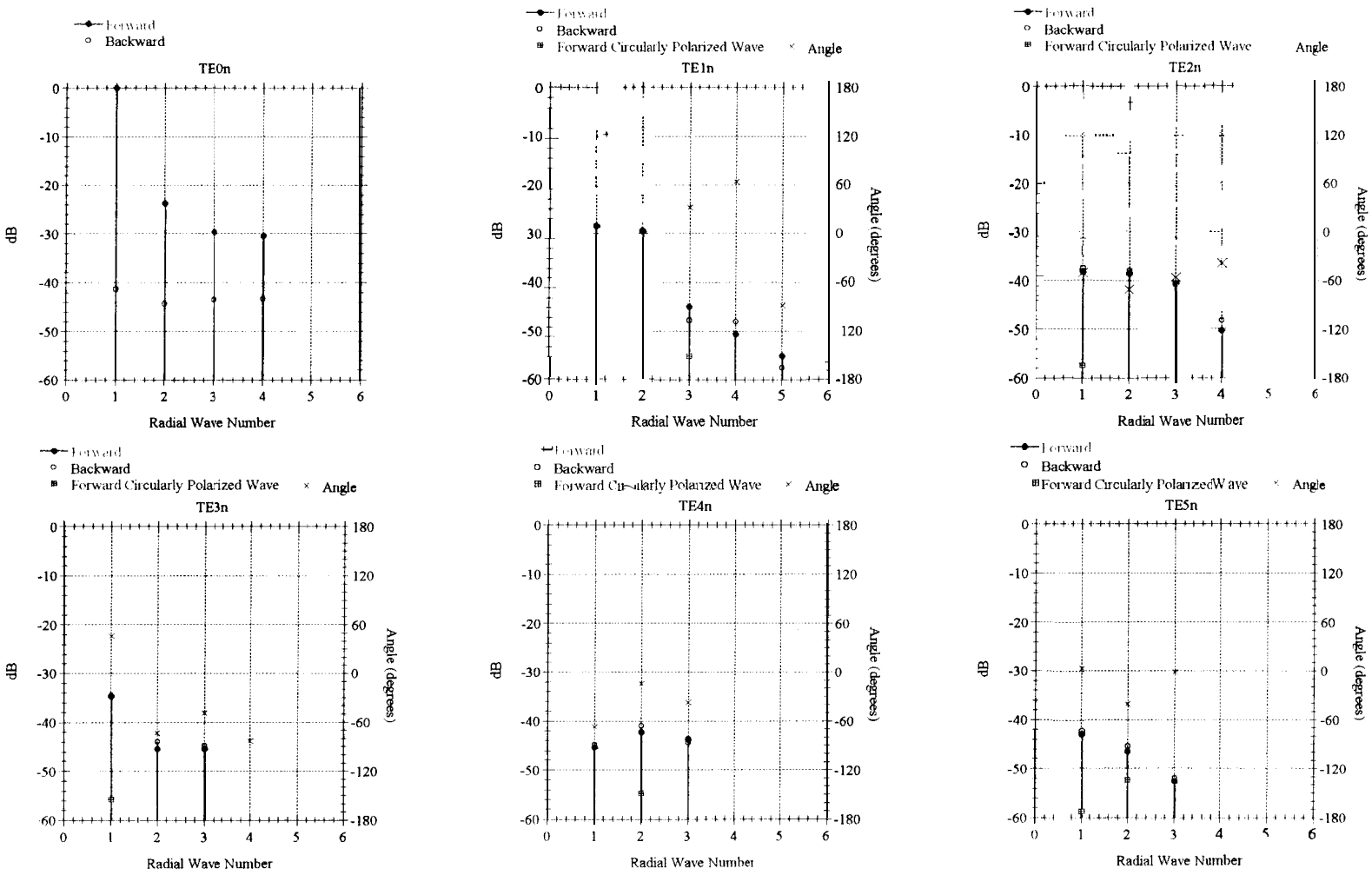


TE_{12} Mode Launcher, a spacer for the mode rotator, nonlinear taper and, transport line

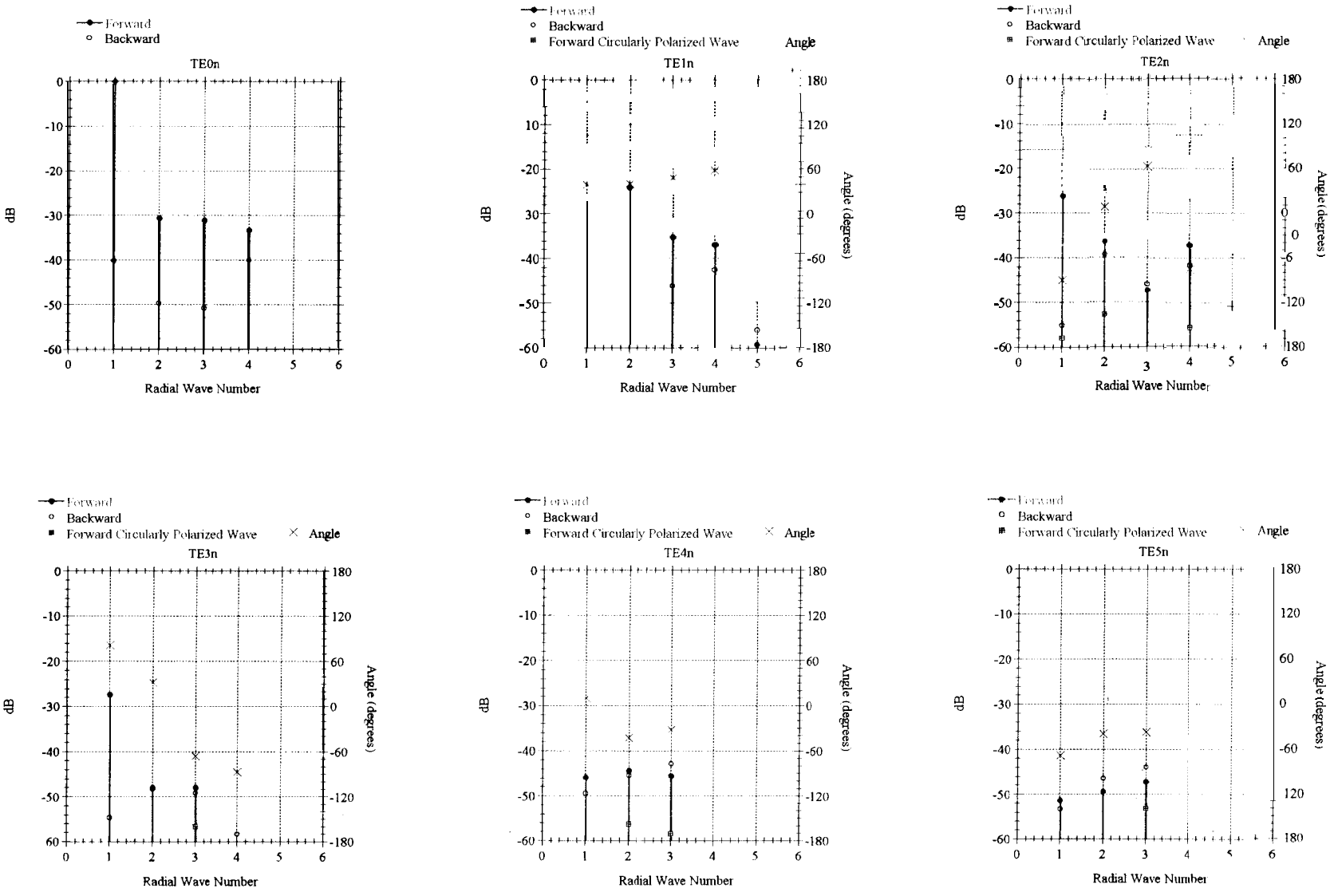


The end of the mode analyzer and transport line is terminated by a multi-moded load

Measured Mode spectrum of the TE_{01} mode transducer.



Mode Spectrum after the 55 meter of Waveguide.
The mode is Launched using SLAC's TE_{01} mode converter



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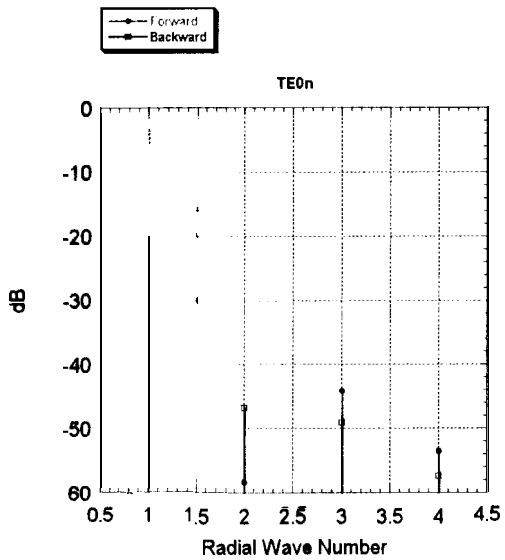
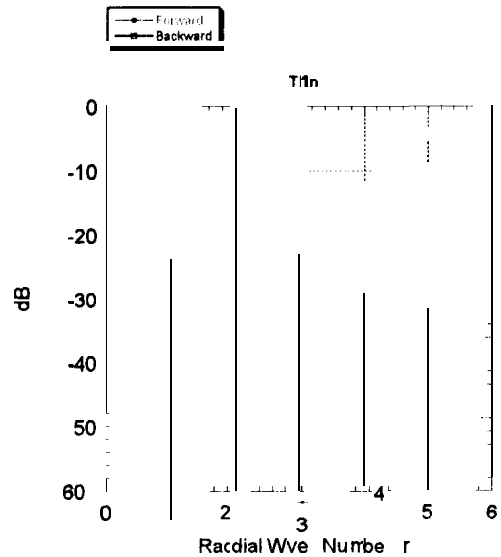
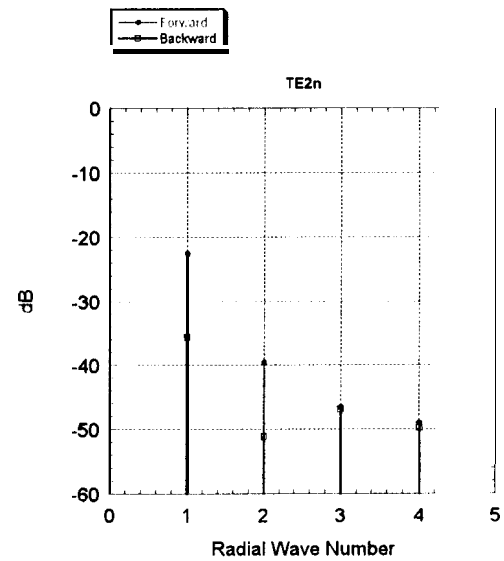
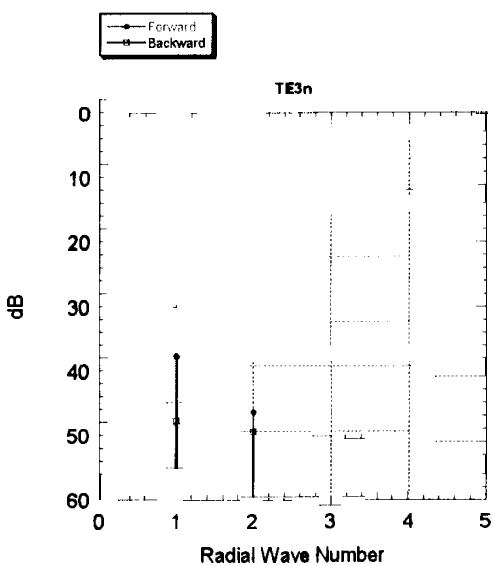
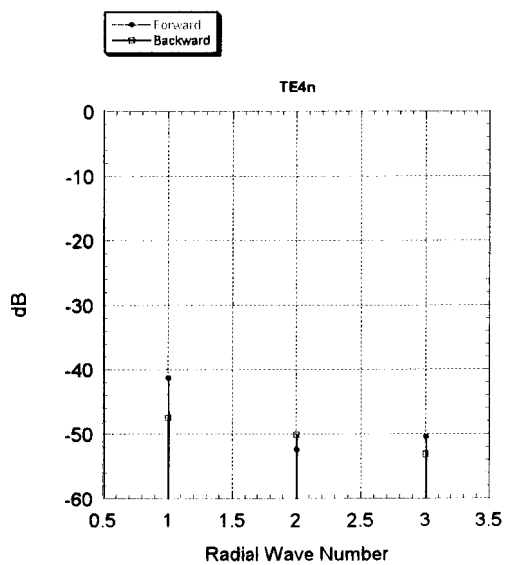
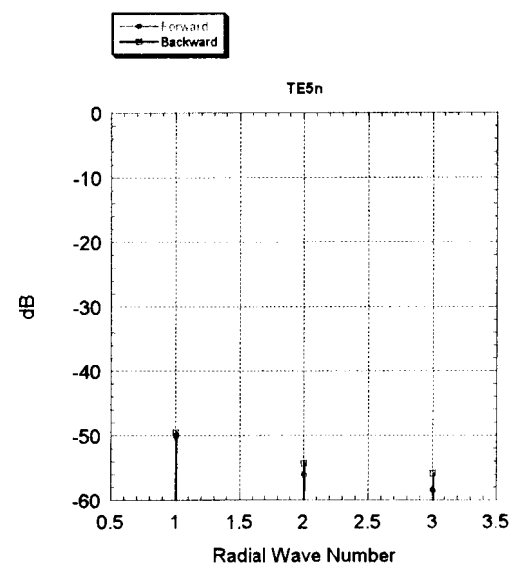


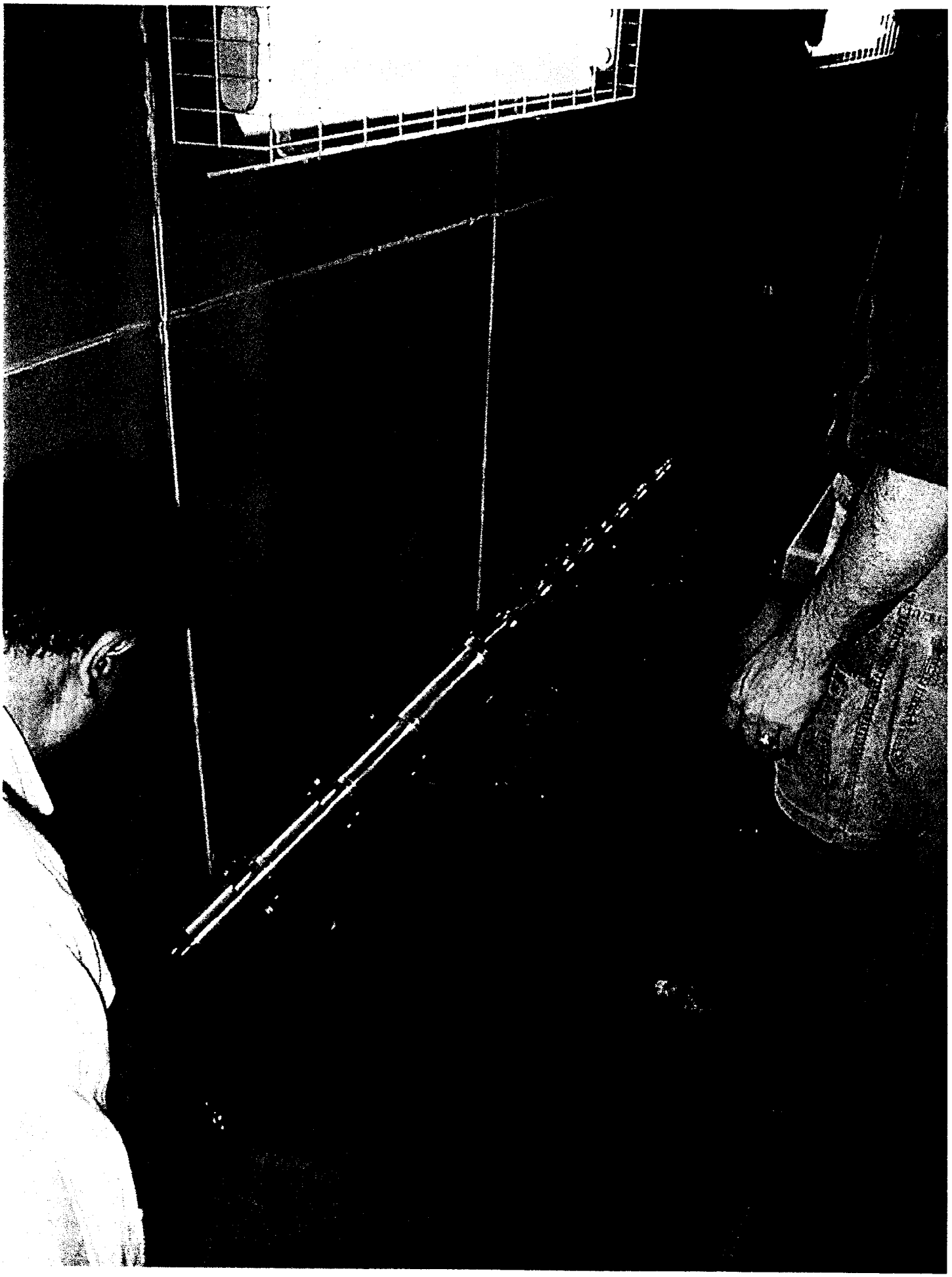




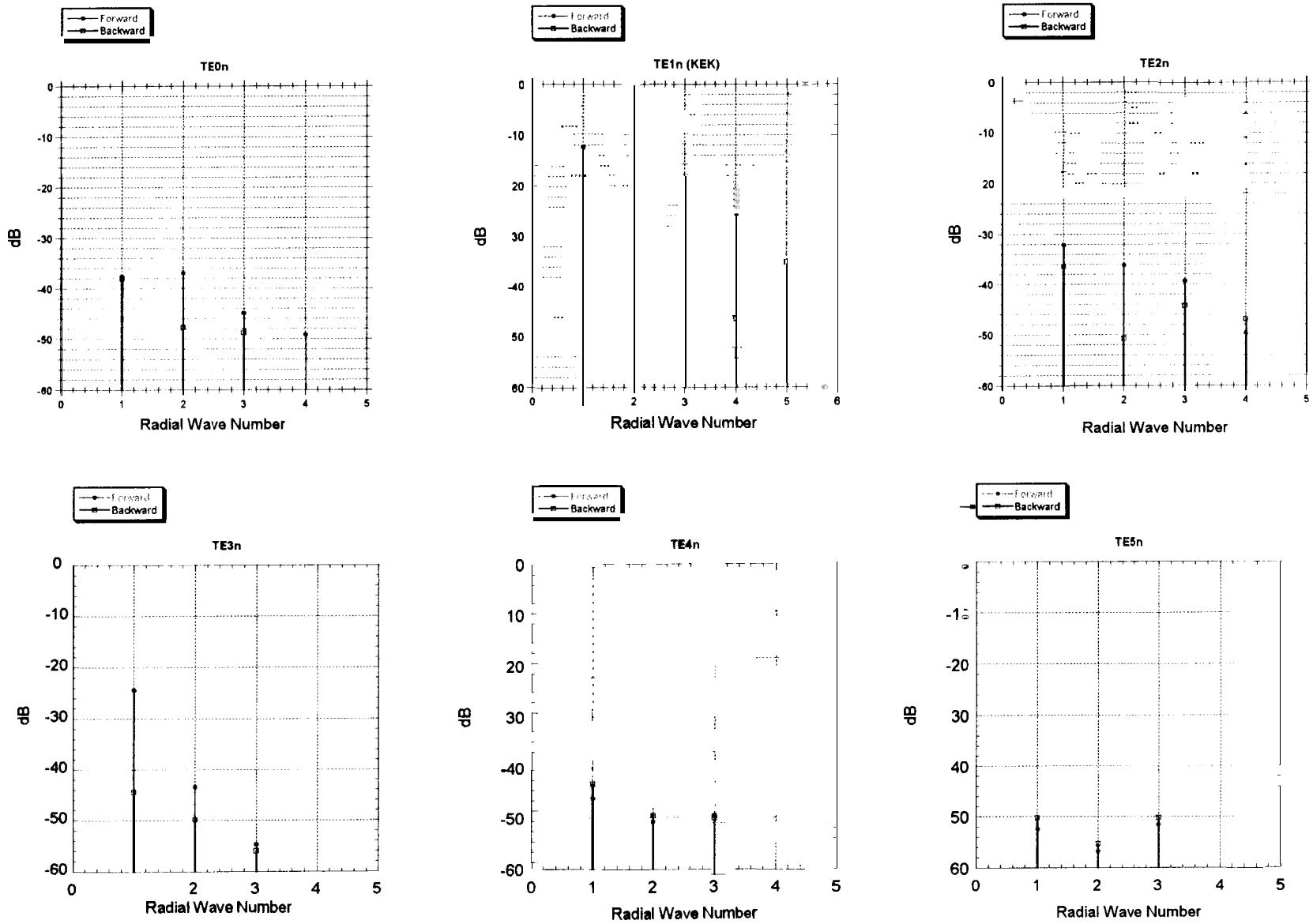




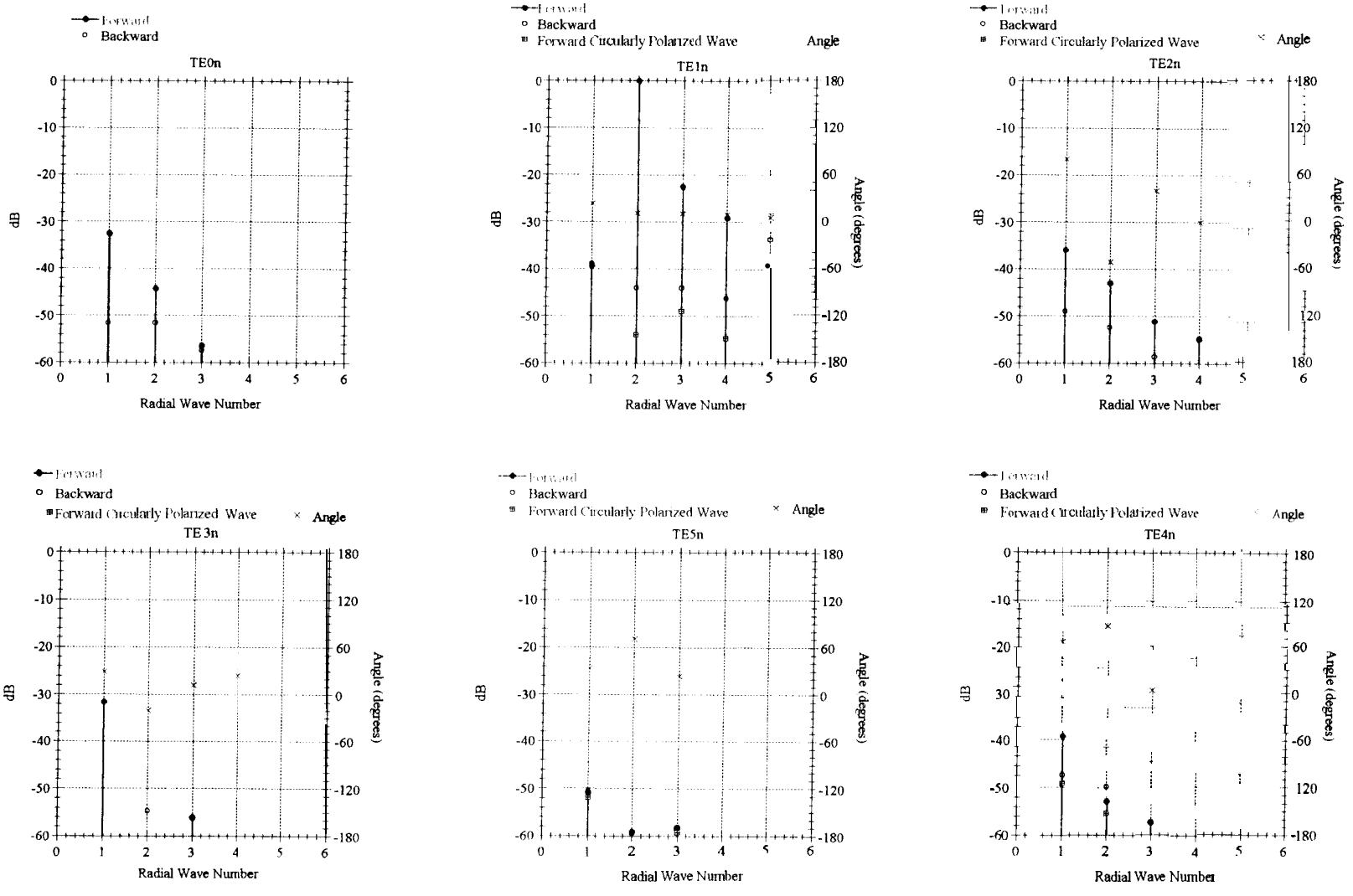




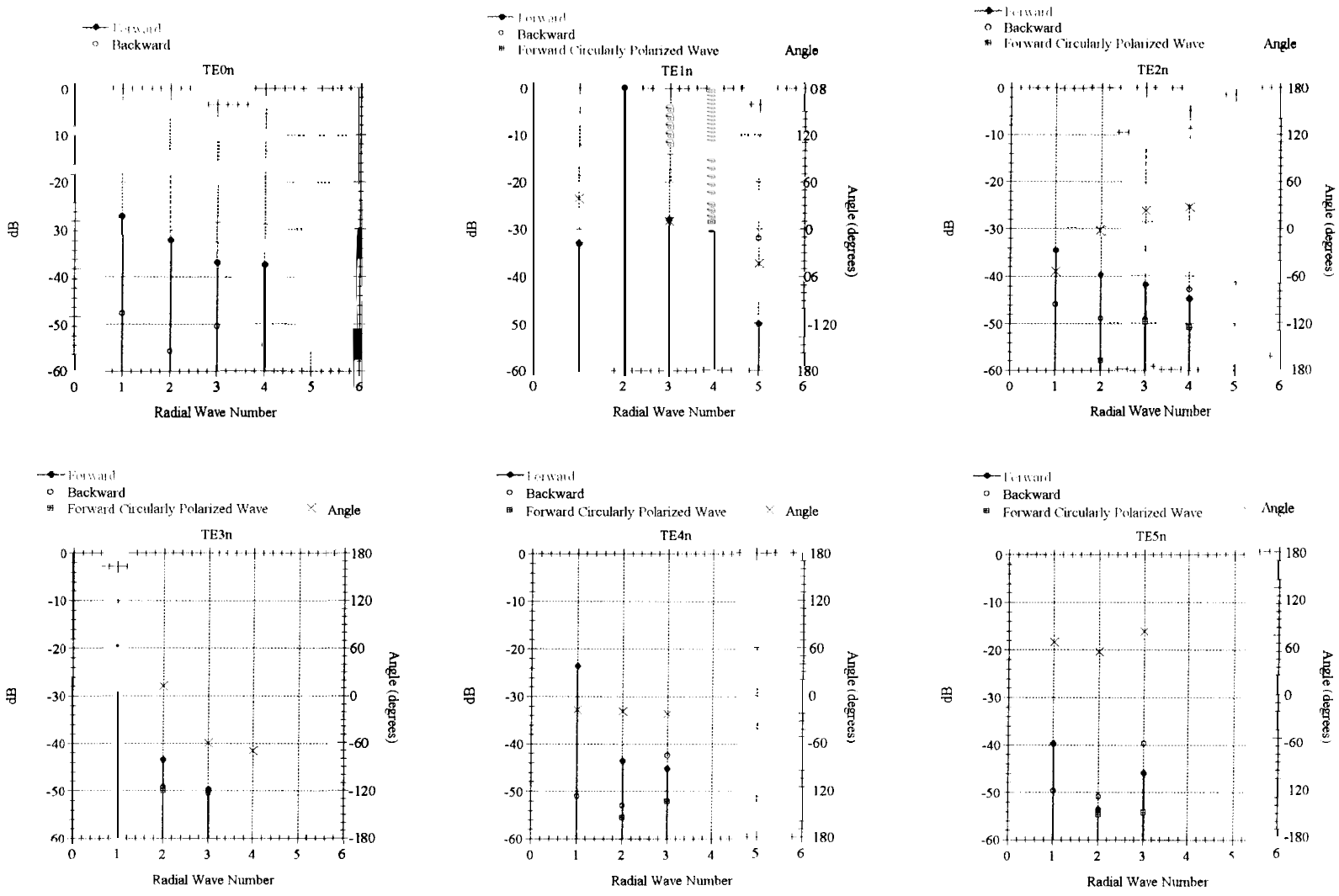
Mode Spectrum of the KEK Mode Launcher

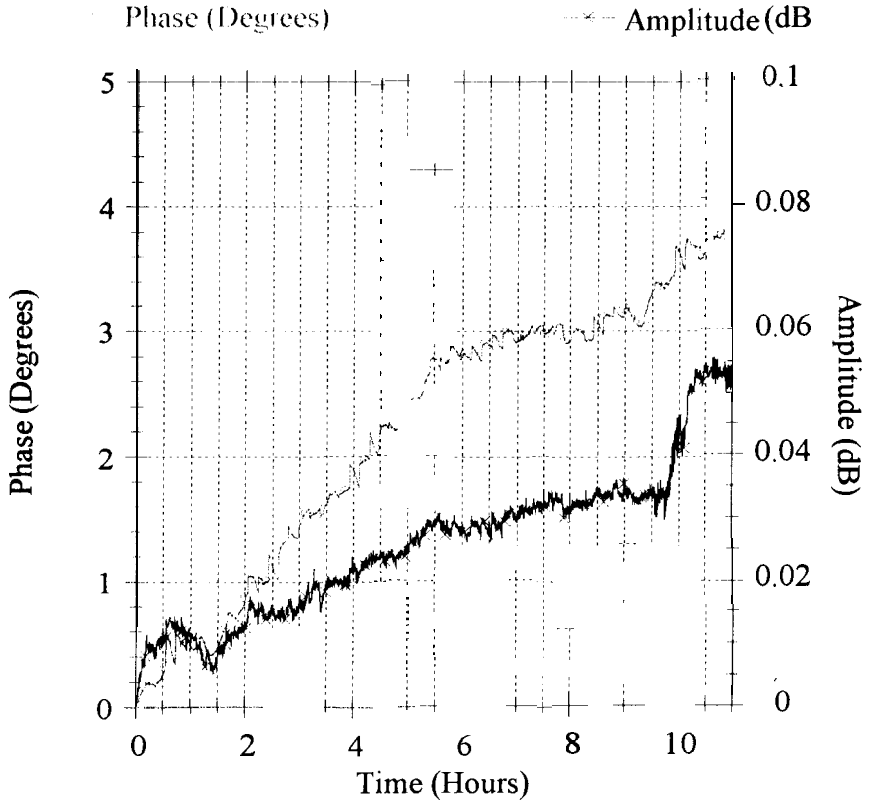


SLAC's TE_{12} mode launcher

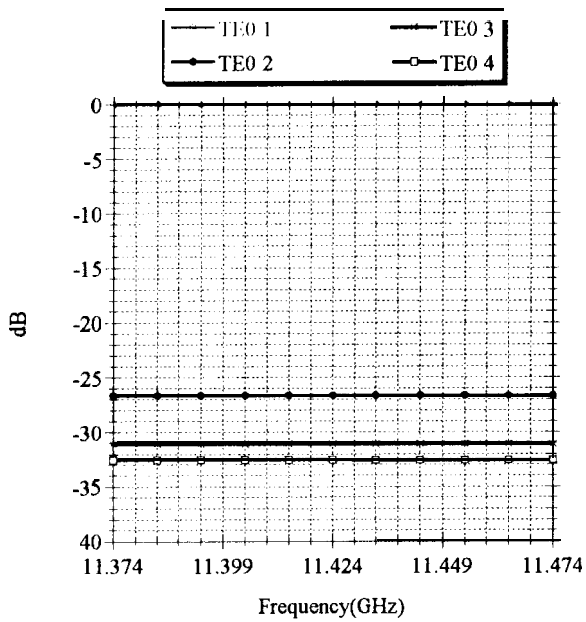


Mode Spectrum after the 55 meter of Waveguide.
The mode is Launched using SLAC's TE_{12} mode converter

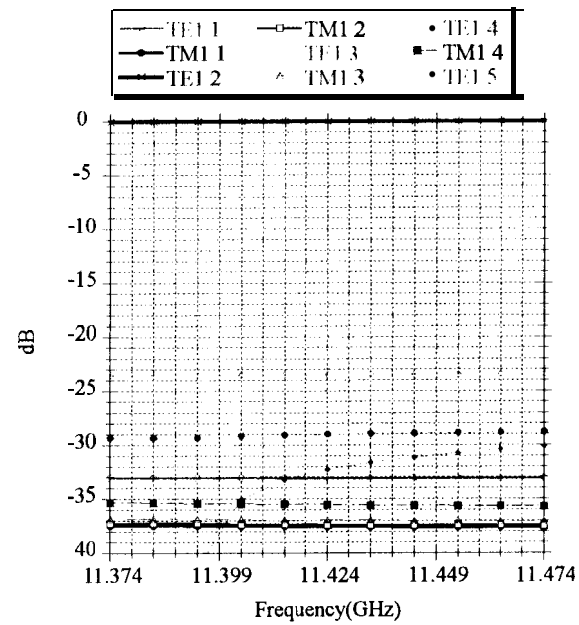




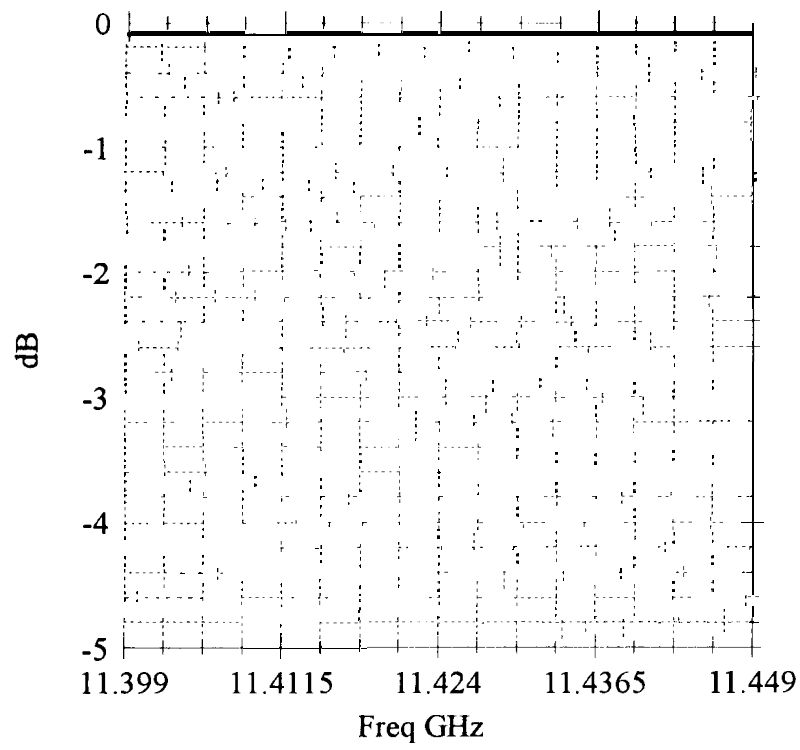
Stability of measurements over time



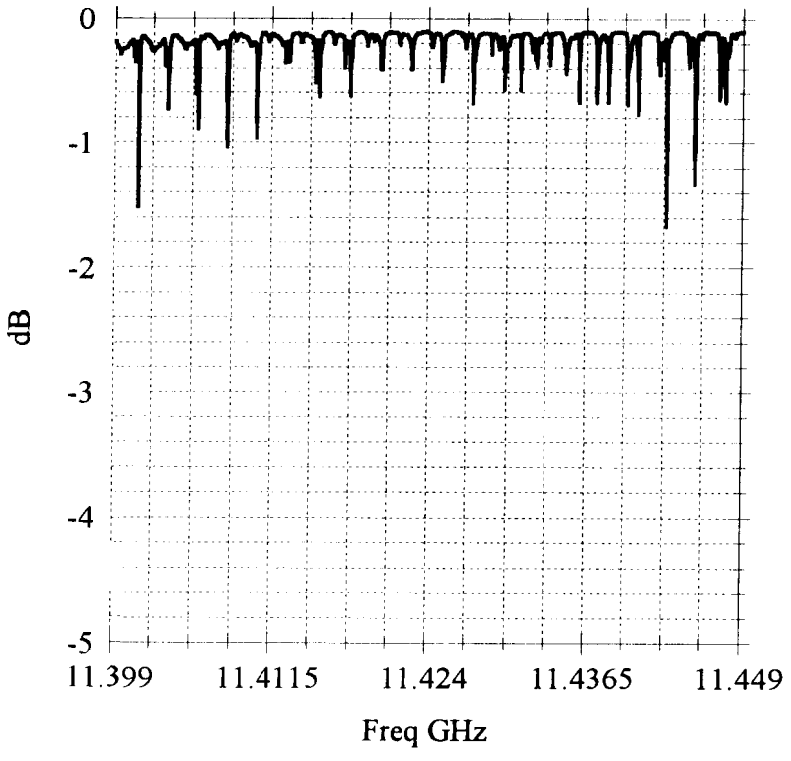
The scattering of modes due to the step discontinuity when an incident mode is the TE_{01} mode

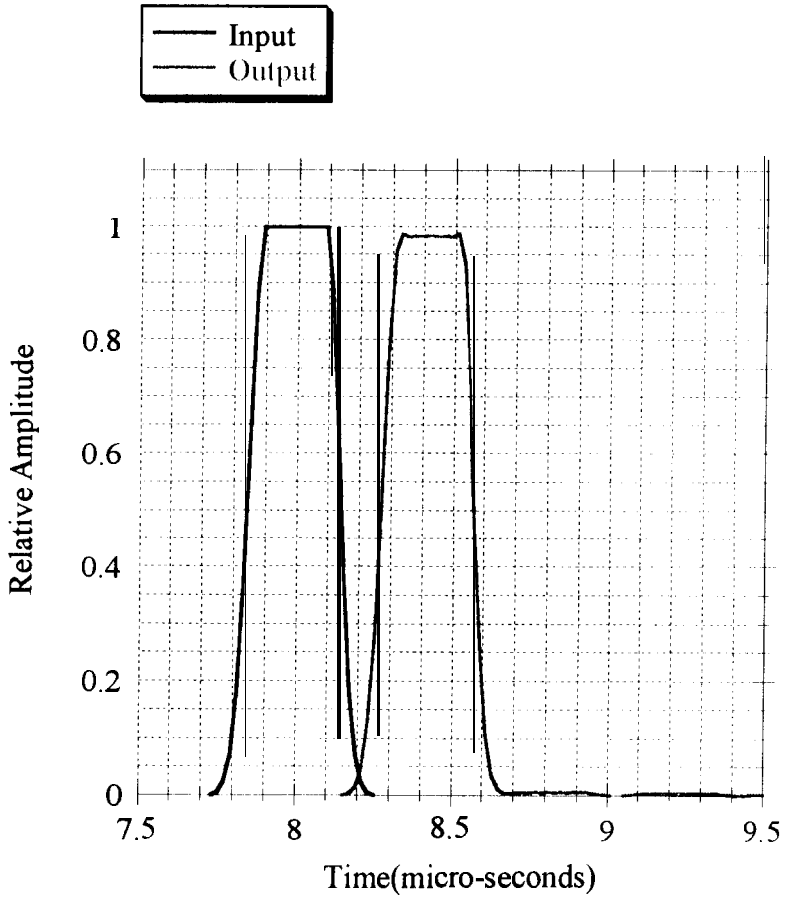


The scattering of modes due to the step discontinuity when an incident mode is the TE_{12} mode

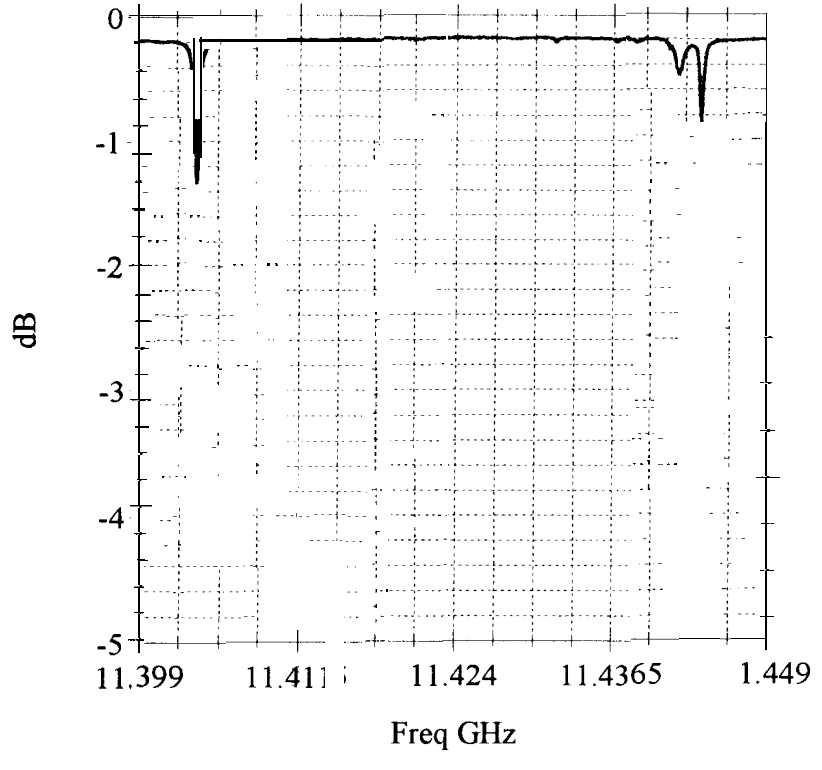


Two TE_{01} mode converters back to back including up tapers to 4.75" diameter

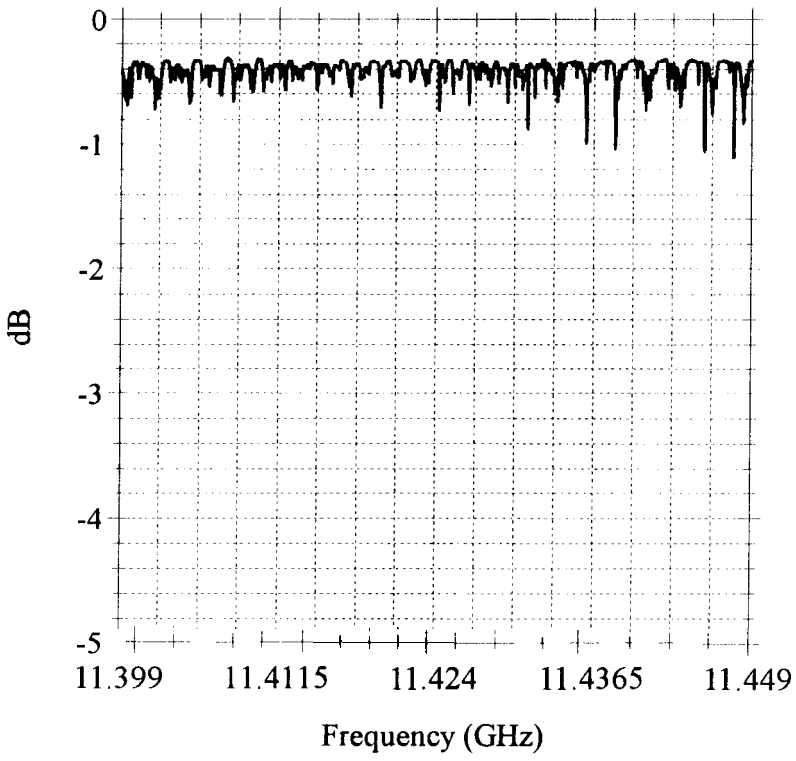


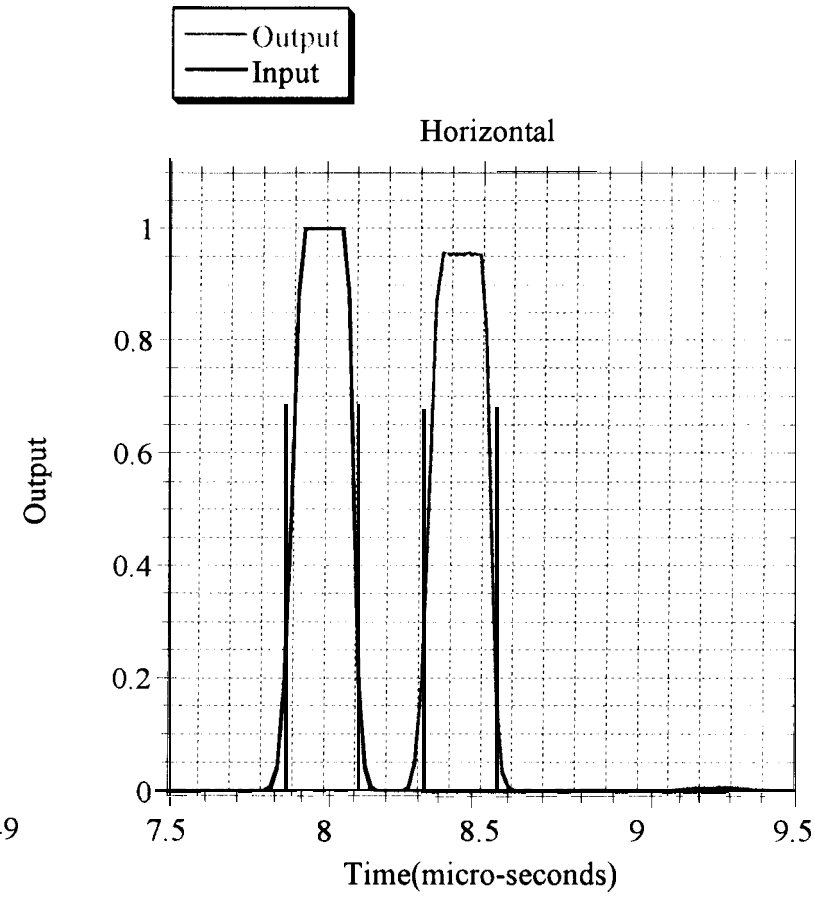


Time domain response of the transport line plus the mode launchers (two TE_{01} mode transducers plus two arc-tapers).

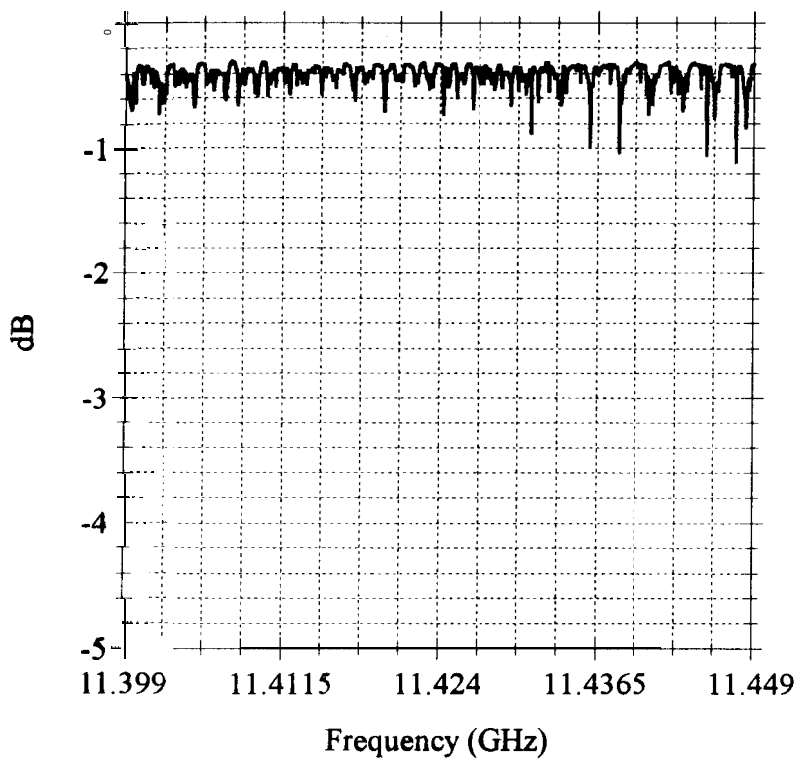


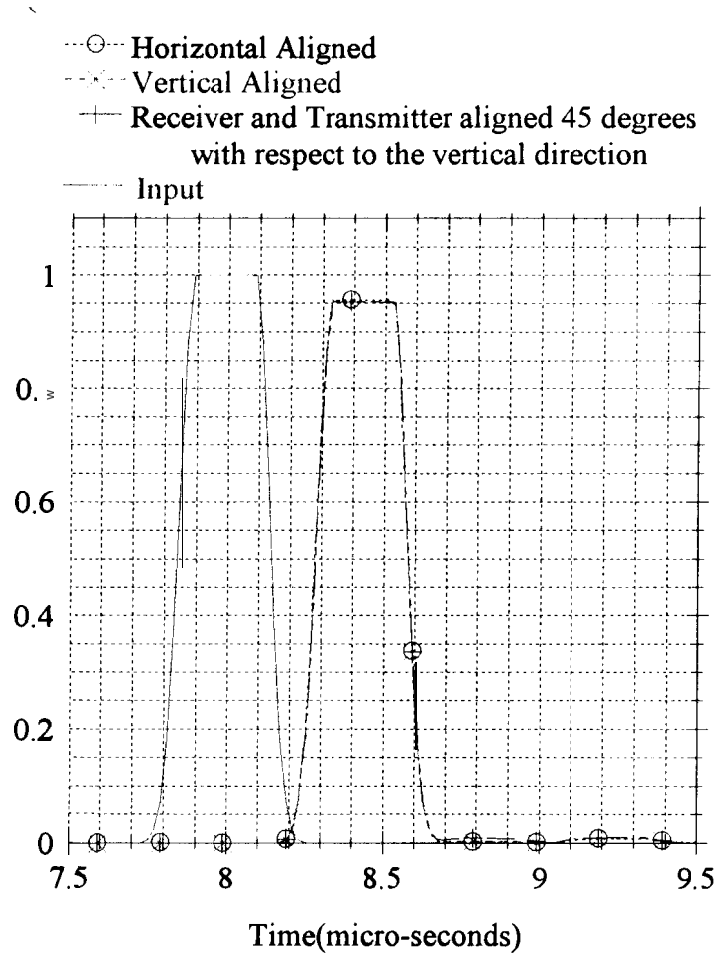
Two TE_{12} mode converters back to back including up tapers to 4.75" diameter



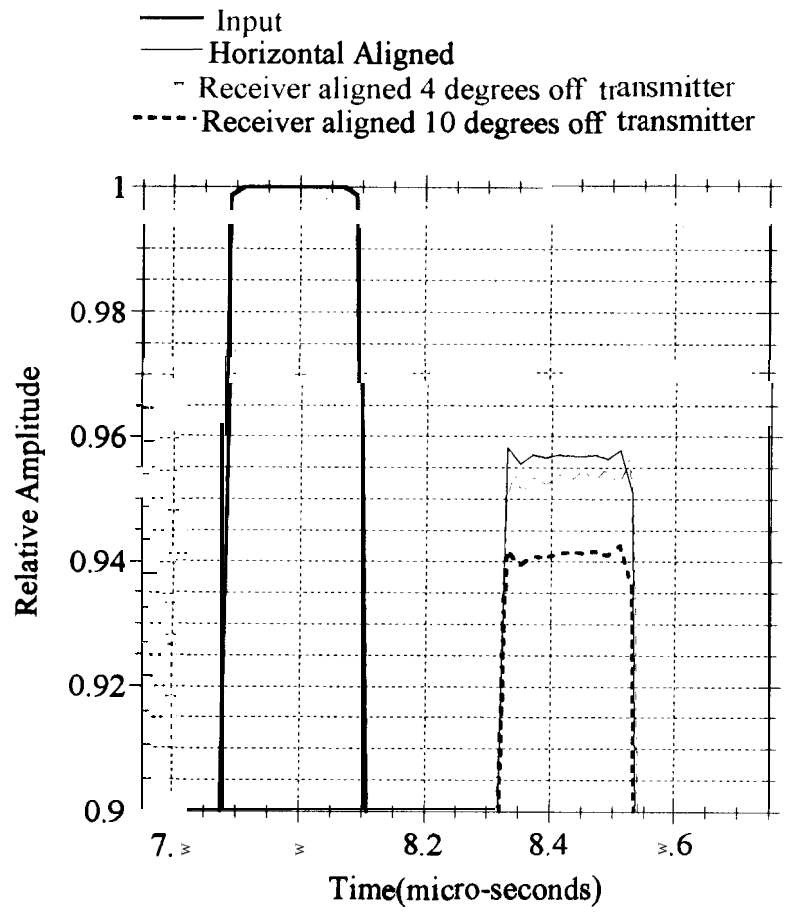


Transmission Measurement through a TE_{12} mode launcher 55-meter of WC475 Waveguide and a receiving TE12 Mode Converter. The TE_{12} was Launched and received with horizontal polarization





Time domain response of the transport line plus the mode launchers (two mode transducers plus two arc-tapers). In this figure the two mode transducers were always aligned with respect to each other



The effect of rotating one of the mode TE_{12} mode transducer with respect to the other.

Conclusion

- We have demonstrated the possibility of using the TE_{12} mode in highly over-moded circular waveguides as a means of low-loss transport of rf signals. The over all losses were small and compared relatively well with theory.

- The waveguide used in the experiments were extruded oxygen-free high-conductivity copper. It was shown that these waveguides could be manufactured good enough to eliminate all cross polarization mode mixing. Nonetheless, we observed some conversion to the virtually degenerate mode, TE_{41}. However, the conversion levels were small.

- We also compared our results for TE_{12} with those of the low loss TE_{01}. In this process we showed that connecting flanges and waveguides could be used to propagate either modes. This paves the way to developing a multi-moded system were different signals could be loaded over different modes.

- We reported a novel technique for measuring the modal content of a highly over-moded waveguides. We also, reported a technique for efficiently exiting the TE_{12} mode and the TE_{01} mode. Finally, we showed how to design and implement a polarization rotator for the TE_{12} mode.

- Over the 55 meter of WC475 losses of The TE_{01} Mode is 1.08%; Theory is 1.1%. Losses of the TE_{12} Mode is 4.5% to 5.1%; theory is 2.8%