Characterization of a Compact Water Vapor Radiometer for the VLA

Ajay Gill[1,2], Robert Selina[2]
[1]University of Toronto, Toronto, ON, Canada, M5S 3G4
[2]National Radio Astronomy Observatory, Socorro, New Mexico 87801

Introduction

The Compact Water Vapor Radiometer (CWVR) is a pathfinder project to evaluate the use of waver vapor radiometry for phase calibration of the ngVLA. We report on lab results of the CWVR, a five channel design centered around the 22 GHz water vapor line.

Background

Fluctuations in perceptible water vapor cause fluctuations in the atmospheric emission, which are assumed to be proportional to phase fluctuations of the astronomical signal seen by an antenna. The CWVR is intended to support empirical radiometric phase corrections for each baseline in the array.

Dynamic Range

The dynamic range of the CWVR was measured to be ~ 18 dbm, as shown in Figure 1.

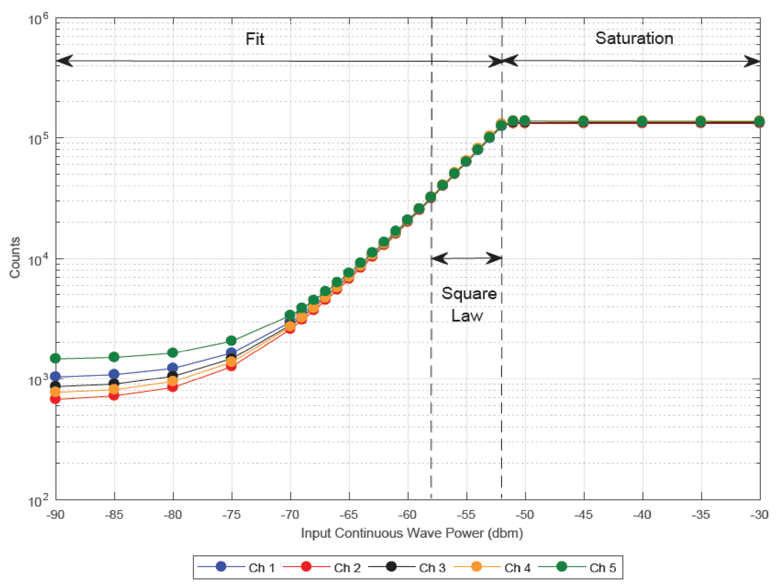

Fig.1: Dynamic range of the CWVR

Temperature Stability

The temperature stability of the CWVR was measured to be < 25 mK over a 64 hour period, which meets the requirement, as shown in Figure 2.

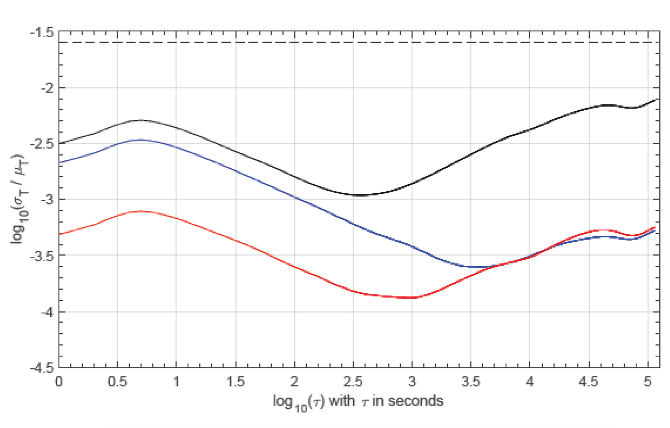

Fig. 2: Temperature stability of the CWVR

Channel Isolation

The channel isolation was determined to be < -20 dB, indicating < 1% power leakage between any two channels, which meets the requirement. The power response of the CWVR is shown in Figure 3.

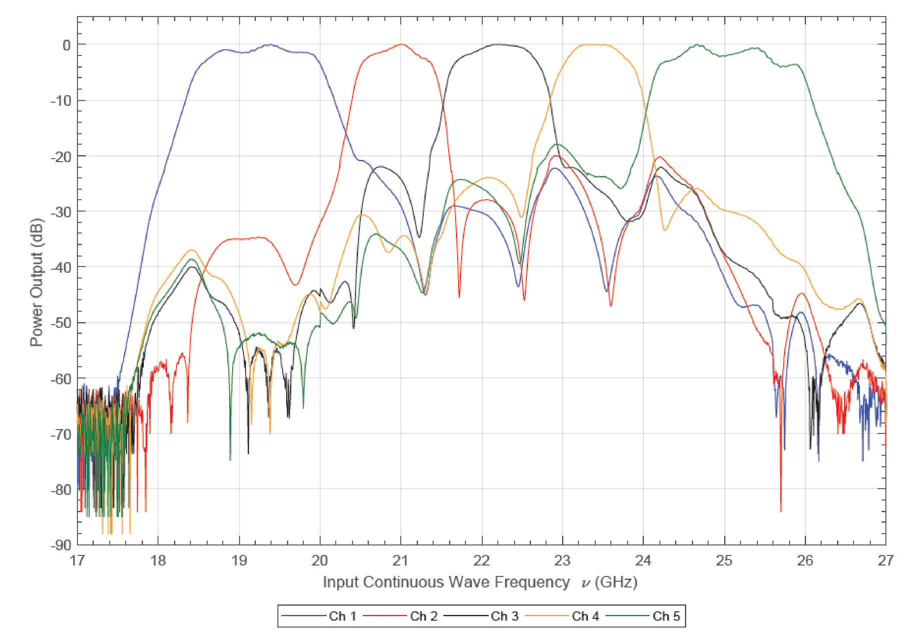

Fig. 3: Power response of CWVR vs frequency

Single Channel and Observable Gain Stability

The single channel and observable gain stability requirement is 2 – 4 x 10^{-4} over a timescale of 2.5 – 10^3 sec. The Allan Standard Deviations (ASDs) shown in Figure 4 and 5 indicate that the stability requirement was met.

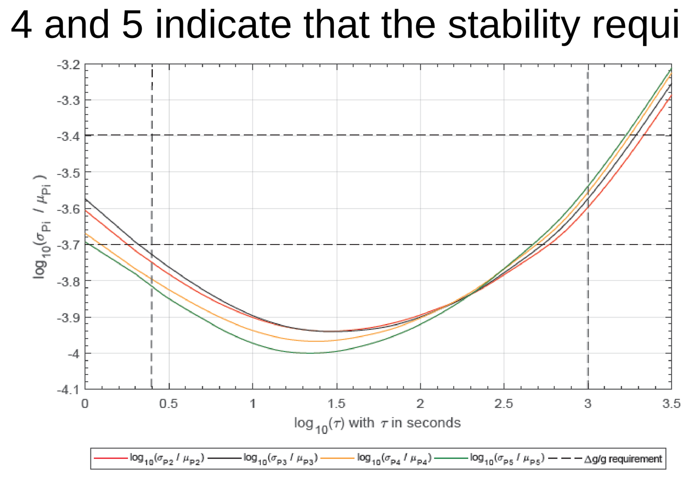

Fig. 4: Single channel ASDs over 64 hours

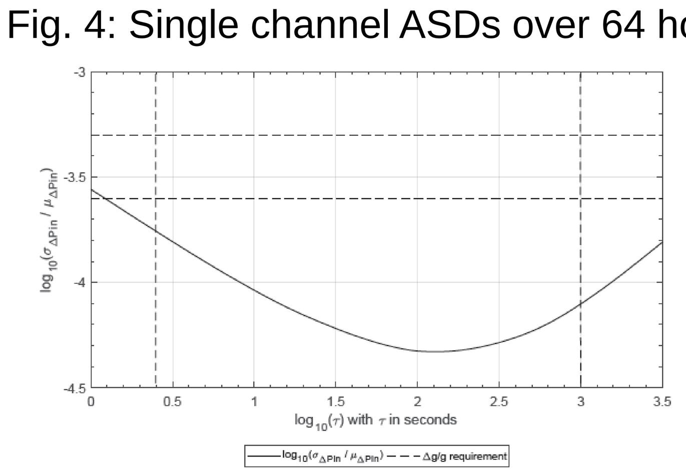

Fig. 5: Observable ASD over 64 hours

Temperature Correlation

The fluctuations in channel output counts were found to be strongly correlated to the temperature fluctuations inside the CWVR device, as seen in Figure 6, with a correlation coefficient of -0.83.

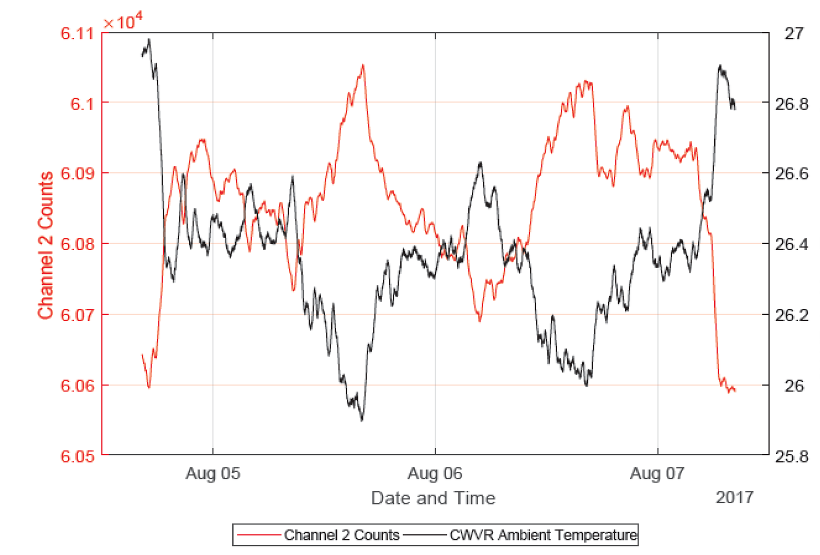

Fig. 6: Correlation between output counts and temperature

Temperature Correction

The output counts were temperature corrected to further improve the gain stability of the CWVR, as seen in Figure 7 and 8.

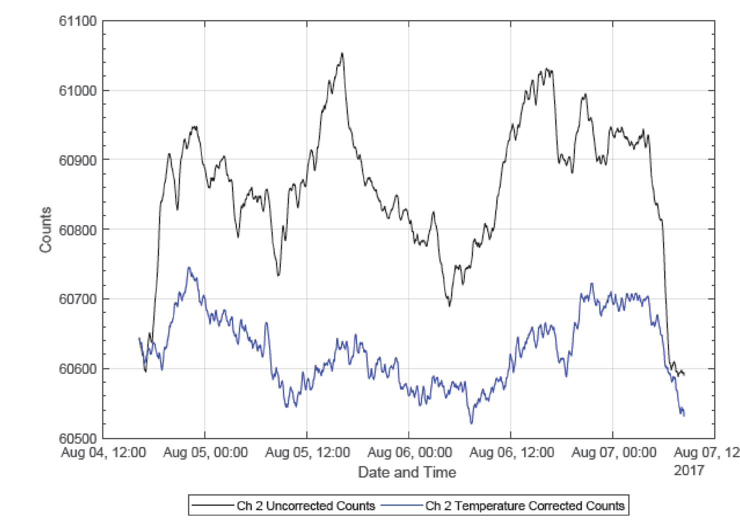

Fig. 7: Temperature corrected Channel 2 output counts

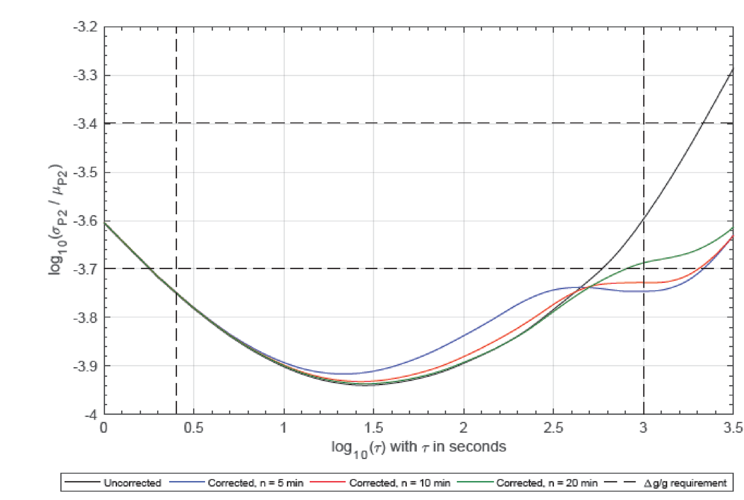

Fig. 8: Single Channel ASDs with temperature correction

Conclusions and Future Work

The CWVR meets the key identified requirements. Next, we plan to build and install four CWVRs on the VLA for further empirical testing and on-sky characterization to evaluate WVR for phase calibration of the ngVLA.

References

1) Gill, Ajay et al. A Study of the Compact Water Vapor Radiometer for Phase Calibration of the Karl G. Jansky Very Large Array, NRAO EVLA Memo # 203, 2017.
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3) Chandler, C. J, Brisken, W. F, Butler, B. J, Hayward, R. H, M.,Willoughby, B. E, Results of Water Vapor Radiometry Tests at the VLA, EVLA Memo # 73, 2004.

Acknowledgments

The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc. This work was possible through the National Radio Astronomy Observatory Graduate Student Research Assistantship program. We thank the NRAO Socorro Electronics Division staff for their support and cooperation.

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