EVLA Memo 124
Wide-band Sensitivity of K- and Q-Bands for the EVLA and VLA

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Abstract

A comparison of the sensitivity of the VLA to EVLA antennas across K- and Q-band has been measured. The results show that both VLA and EVLA antennas at K-band are surpassing the project requirements, whereas the sensitivity at Q-band is below the project requirements and the cause is likely due to the optical alignment of the subreflector and the antenna efficiency. The optical alignment is currently being corrected and the efficiency can be improved by holography.

1 Introduction

A sensitivity analysis of the two arrays has been performed to determine the differences between the VLA and the EVLA, and if the EVLA project sensitivity requirements are being met. The results of these observations and analysis are presented.

2 Observations

Observations were performed on clear and dry days using sources 0217+738 (K- and Q-band) and 1800+784 (K-band) in continuum mode with 50 MHz bandwidth. These are sources with known flux densities which have been measured by comparison with 3C48. Referenced pointing was performed in K- and Q-band before the measurements proceeded to ensure the antennas were on source. Durations of 1 minute were performed at each frequency setting, frequency increments of 250 MHz and 1 GHz were used at K- and Q-band respectively. Table 1 summarizes the observations in each band.

Band	**Source**	**Frequencies Observed (GHz)**	**Flux Density of Source (Jy)**	**Elevation Degrees**
K	0217+730	$\nu = 17.015 + 0.25 * i,\ i = 0 - 12$	3.29	38.3 - 38.9
K	1800+784	$\nu = 17.015 + 0.25 * i,\ i = 13 - 43$	2.74	43.0 - 43.6
Q	0217+730	$\nu = 39.015 + 1.00 * i,\ i = 0 - 11$	2.44	44.2 - 44.8

Table 1: Summary of the observations.

3 Analysis and Results

The data were loaded into AIPS as correlation coefficients and calibrated using the standard method. At the calibration stage, the EVLA and VLA antennas were treated separately to ensure

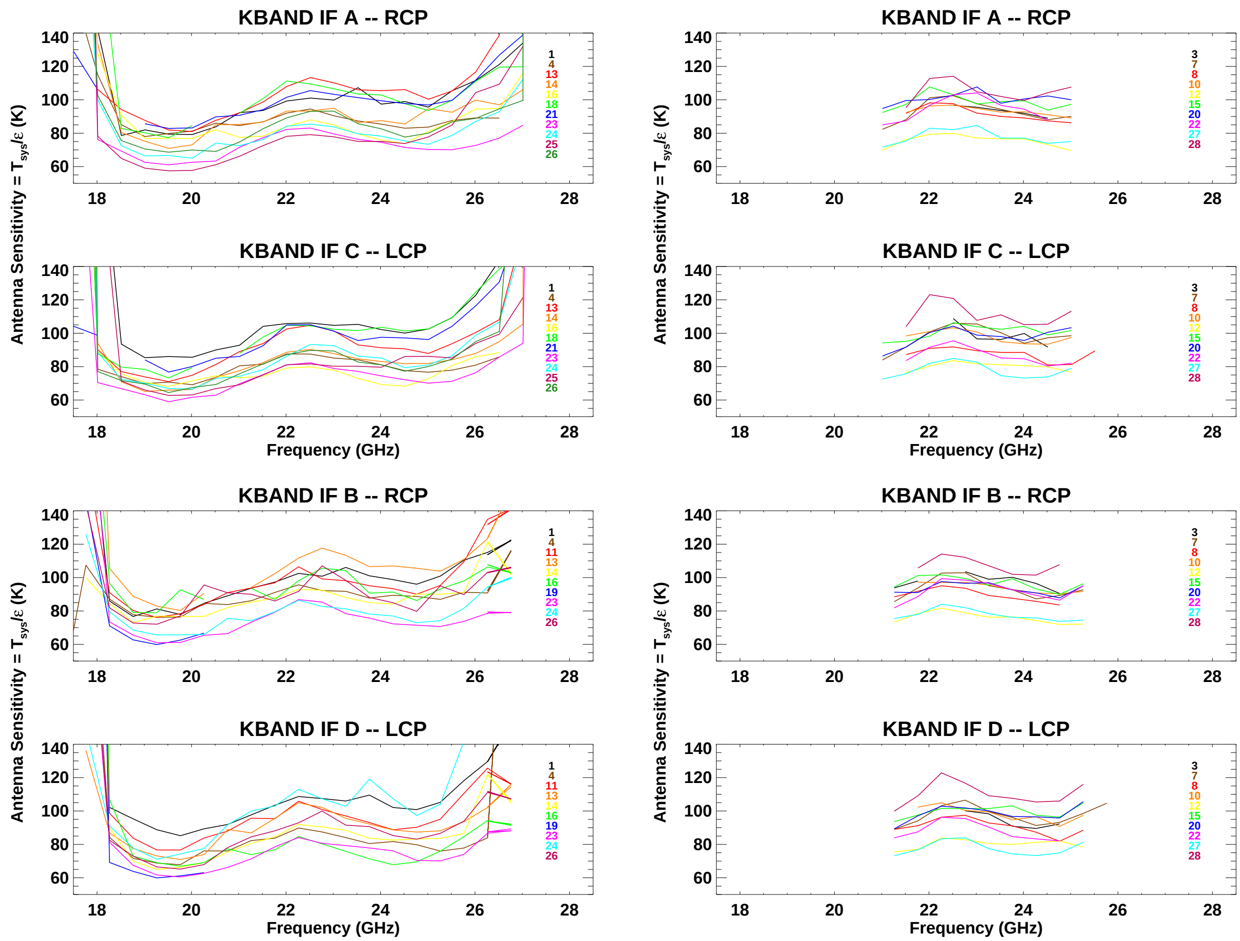

Figure 1: K-band antenna sensitivities. EVLA antennas (left) and VLA antennas (right) for all IF's and polarizations.

that the differing EVLA and VLA bandpasses did not influence the results. The data were read into IDL and the amplitude gain coefficients, A, were converted to sensitivity, T_{sys}/ϵ using (Perley and Hayward, 2008),

$$\frac{T_{sys}}{\epsilon} = 36.8A^2. \tag{1}$$

The sensitivities were examined for EVLA and VLA antennas in each band and the worst antennas were removed from the analysis. Figures 1 - 2 show the individual EVLA and VLA antenna sensitivities. At K-band, the water line from the Earth's atmosphere at approximately 22 GHz is clearly visible. The EVLA antennas show the larger tuning range available. The observations at Q-band show that the sensitivity significantly decreases as the high-edge of the band is reached, due to atmospheric O_2.

At each frequency within each array (VLA and EVLA), the sensitivities for each antenna were averaged to produce a single value with the uncertainty in that value defined as the standard deviation in the mean. Curve fitting was then applied to determine the relation of sensitivity with frequency in each band for VLA and EVLA antennas. Figures 3 – 6 show the results of these calculations and Table 2 presents the sensitivity relations for each band. At K-band, linear curves were fit by neglecting the region of the water line and the band edge effects. Care should be used when observing beyond the tuning ranges of K-band as the sensitivity significantly worsens in these

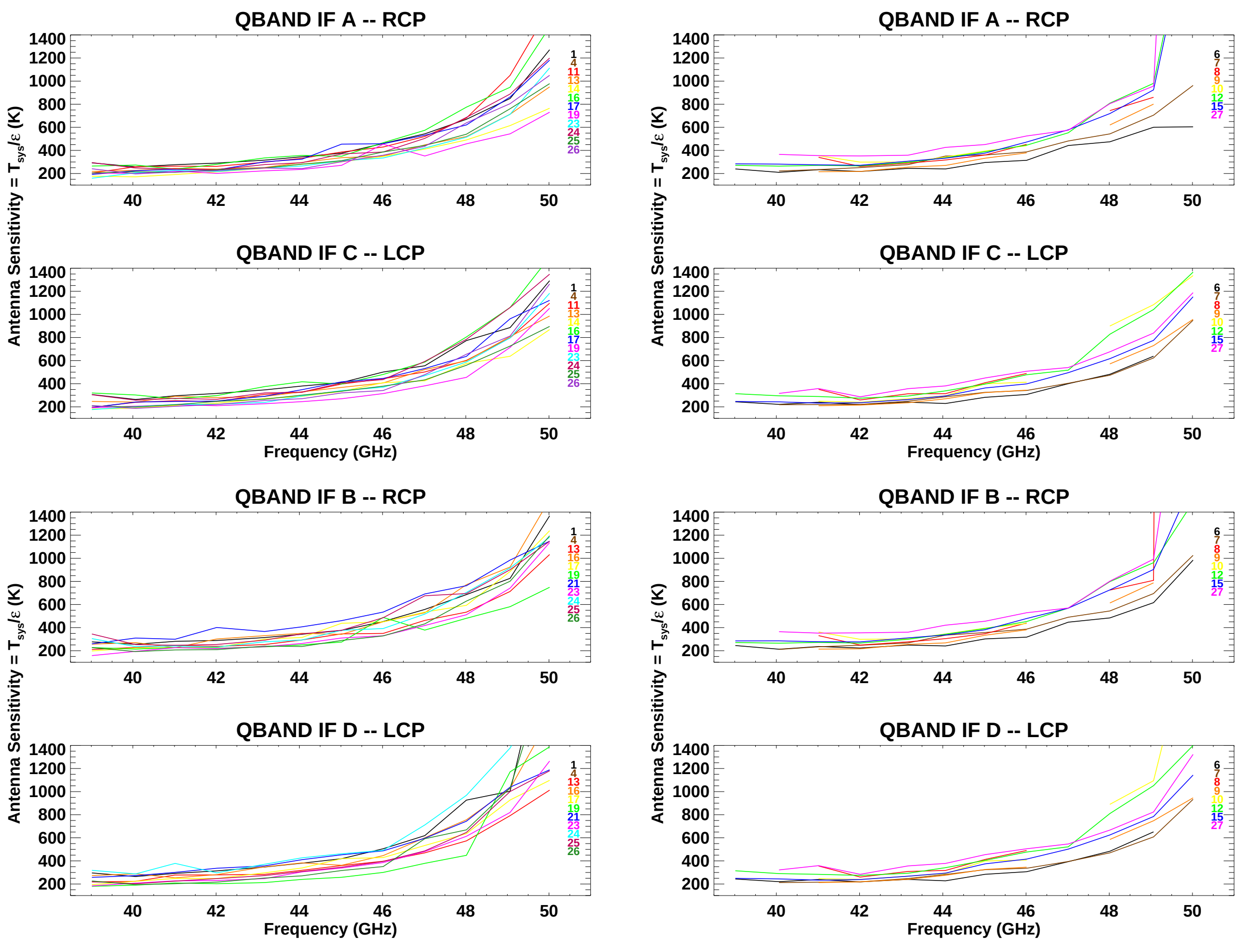

Figure 2: Q-band antenna sensitivities. EVLA antennas (left) and VLA antennas (right) for all IF's and polarizations.

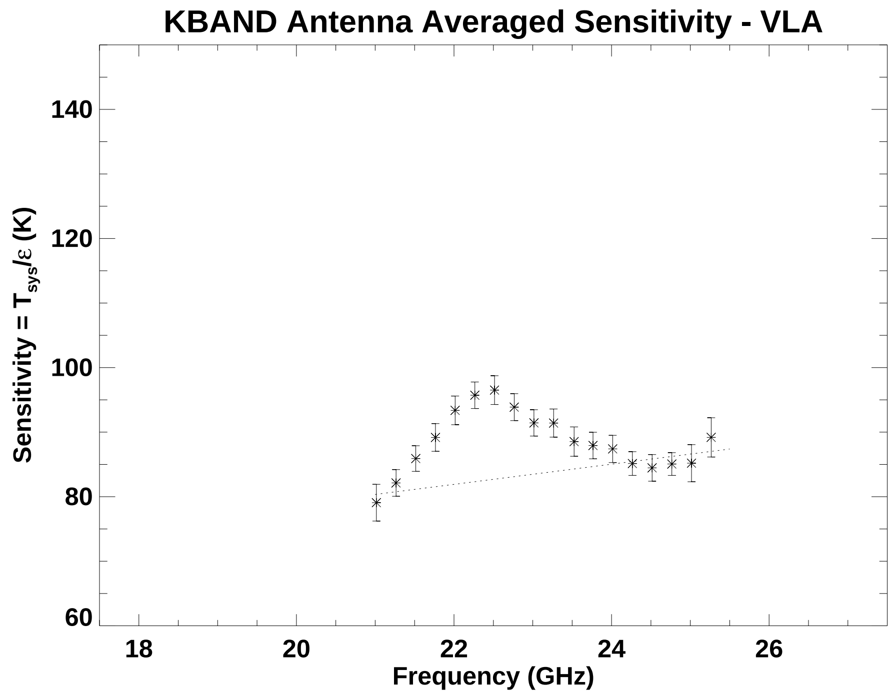

Figure 3: K-band antenna averaged sensitivity values for the VLA antennas and the best-fit straight line curve. The best-fit line was produced by neglecting the region of the water line. The water line reduces the sensitivity by approximately 10 K.

regions. In addition, a loss in sensitivity of approximately 10 K in T_{sys}/ϵ should be expected in the region of the water line. At Q-band, second-order polynomials were fit by excluding the 50 GHz data point.

Band	**Array**	**Sensitivity Relation**
K	VLA	$S(\nu) = 47.5 + 1.6\nu$
K	EVLA	$S(\nu) = 25.5 + 2.2\nu$
Q	VLA	$S(\nu) = 15228 - 724\nu + 8.7\nu^2$
Q	EVLA	$S(\nu) = 14922 - 716\nu + 8.7\nu^2$

Table 2: K- and Q-band sensitivity relations; where $S = \frac{T_{sys}}{\epsilon}$ in K and ν is the frequency in GHz.

4 Conclusions

The sensitivity relations of K-band for VLA and EVLA antennas are similar in magnitude and shape. When the water line and edge-effects of the band are neglected, the sensitivity relations for the VLA and EVLA K-band antennas are a linear relations (Table 2). The Q-band relations are quadratic because of the loss of sensitivity at the high-frequency edge of Q-band. Perley and Rupen, (2006) state the zenith antenna sensitivity requirements for the EVLA project. A comparison between the required antenna sensitivities and the measured values for each array is given in Table 3. The measured antenna sensitivities had to be corrected to zenith to be compared

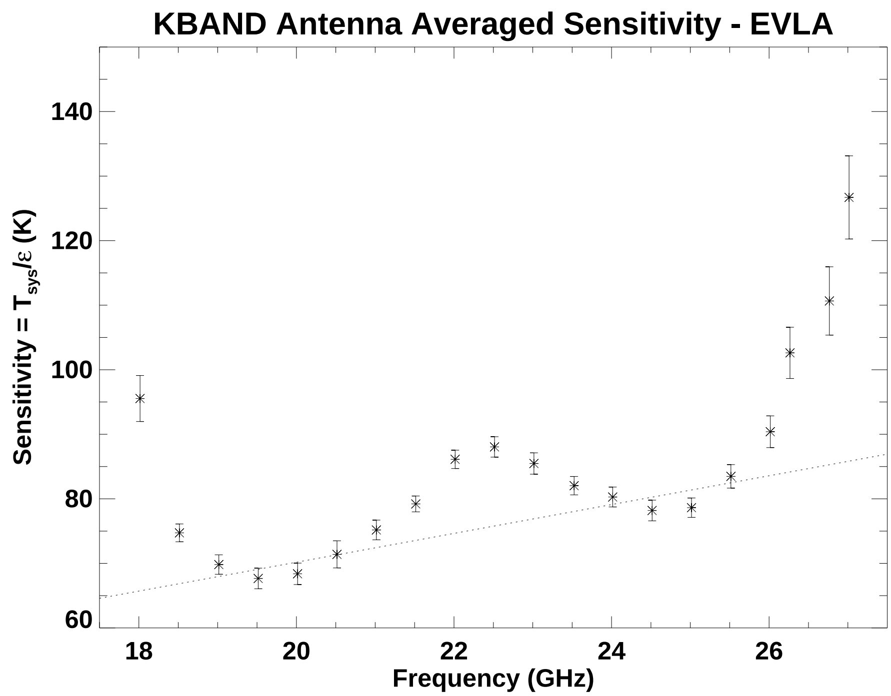

Figure 4: K-band antenna averaged sensitivity values for the EVLA antennas and the best-fit straight line curve. The best-fit line was produced by neglecting the region of the water line and the edges of the band. The water line reduces the sensitivity by approximately 10 K.

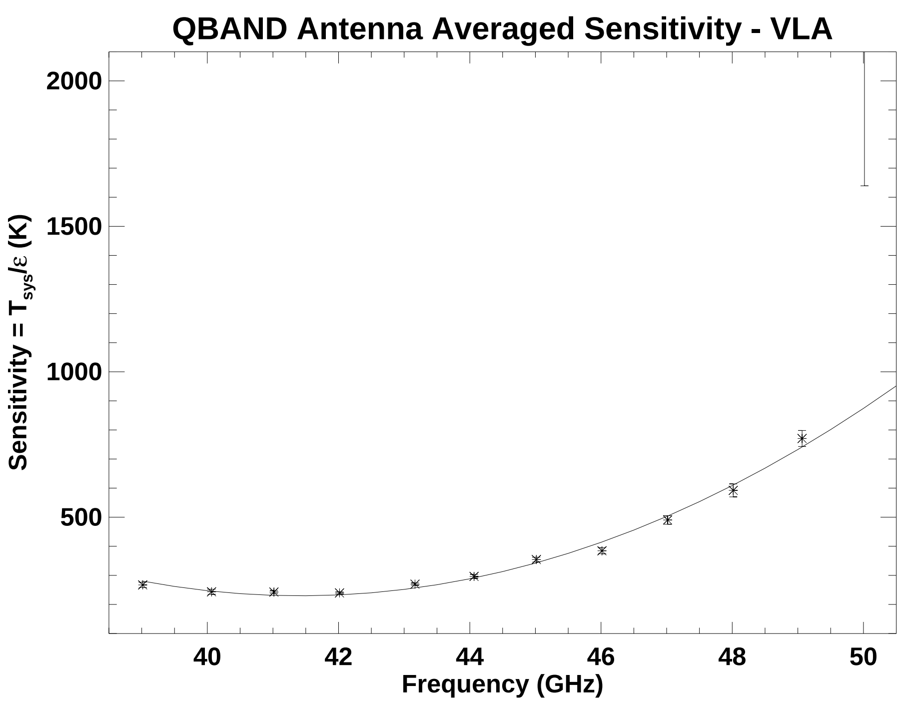

Figure 5: Q-band antenna averaged sensitivity values for the VLA antennas and the best-fit curve.

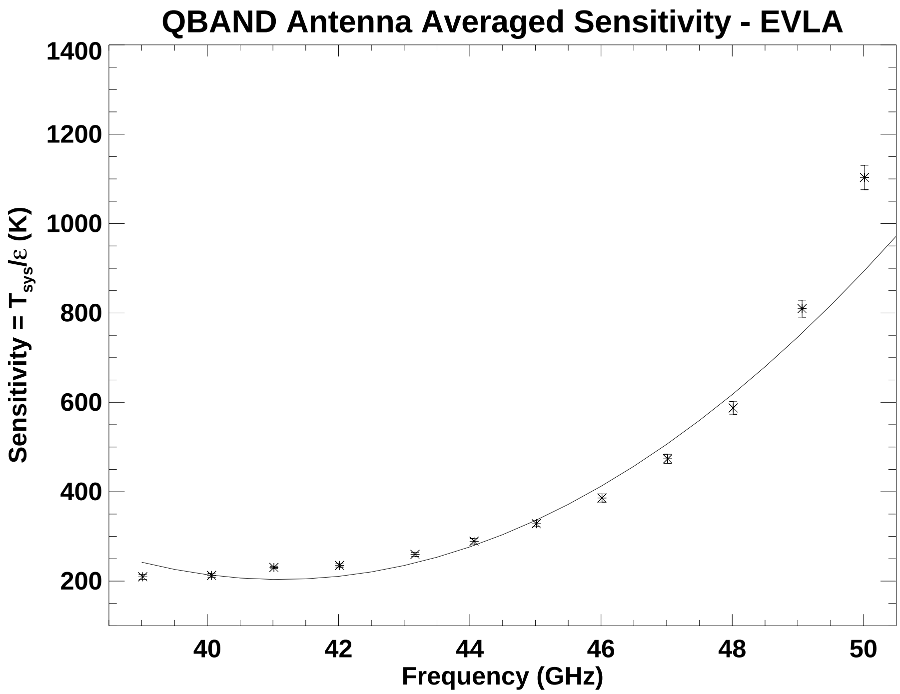

Figure 6: Q-band antenna averaged sensitivity values for the EVLA antennas and the best-fit curve.

to the required sensitivities. Perley et al. (2006) provide the relations of system temperature with airmass so that the observations performed here, at an airmass of approximately 1.4, could be corrected to zenith. At K-band, both the VLA and EVLA are easily meeting the EVLA project requirements; however, the situation is much different at Q-band. The EVLA does not make the requirements at either the low or high end of the band. Examining the individual antenna plots (Figure 2) shows that a few antennas make the requirements at the low end of the band but all antennas fail to meet the requirments at the high-end of Q-band. This could be due to the aperture efficiency; panel adjustments will likely improve the efficiency and thereby the sensitivity. It could also be due to the optical alignment of the subreflector; this issue is currently being investigated.

Band	**Array**	**Required Sensitivity** $\frac{T_{sys}}{\epsilon}$ **(K)**	**Measured Sensitivity** $\frac{T_{sys}}{\epsilon}$ **(K)**
K	VLA		80
K	EVLA	104	72
Q (@ 43 GHz)	VLA		189
Q (@ 43 GHz)	EVLA	217	230
Q (@ 49 GHz)	VLA		630
Q (@ 49 GHz)	EVLA	490	716

Table 3: K- and Q-band required and measured sensitivities for the two arrays. The measured sensitivities have been corrected to the zenith using the relations given in Perley et al. (2006).

5 References

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