EVLA Memo #186
An EVLA Stress Test Primer

Keith Morris, Emmanuel Momjian

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1 Introduction

The EVLA Stress Test is a weekly test and diagnostic observation designed to identify gross system failures. The test consists of observing one of three strong calibrator sources for approximately two minutes per receiver band. High frequency bands use X-band reference pointing. With the extra pointings and the antenna and subreflector slew times, the total execution time for the stress test is approximately 30 minutes. An AIPS script automates the reduction and processing of the data, and produces separate data files for each of:

- Total power (P_{SUM})
- Uncalibrated gain
- System temperature (T_{SYS})
- Calibrated gain
- Delays
- System Equivalent Flux Density (SEFD)

The EVLA operators produce a report following the AIPS processing of each stress test. The report consists of a three-page pdf – one page for each of uncal gain, TSYS, and calibrated gain. Values that are outside of the allowed limits for any quantity have been highlighted with a box, which allows a quick method of identifying problem values. The reports appear at \\Andy\evlaops\StressTestReports (Windows) or /users/evlaops/StressTestReports/ (Linux). Figure 1 shows an example of such a report. As is often the case during summer months, K, A, and Q band data are nearly all flagged for out-of-range values.

2 Definitions

System temperature (T_{SYS}) is the sum of receiver temperature, antenna temperature and sky temperature, expressed in Kelvin.

Uncalibrated gain is an amplitude-calibration gain factor. It is the digital gain that normalizes the visibility amplitude. It has been called "uncalibrated" because the visibilities were not calibrated with the switched power gain correction.

Calibrated gain is also an amplitude-calibration gain factor, but here the visibilities were calibrated with the switched power before deriving the gain factors. As such, calibrated gain includes information about the switched power signal.

P_{sum} is the total power measured from the visibility data and is defined as $2*(P_{\text{noise diode on}} + P_{\text{noise diode off}})$, and is a measure of the total power of the source.

Uncalibrated Gain Report for Stress Test Data: 2014SEP17_1841

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	27	28
L Band																											
IF A	63	59	61	61	61	65	56	62	67	64	62	61	60	64	59	63	60	64	68	66	65	65	56	63	59	61	60
IF B	64	60	62	61	59	65	56	63	67	66	62	61	62	66	59	62	61	64	68	64	66	65	56	64	58	59	61
IF C	64	60	61	60	60	65	56	63	65	64	61	61	61	66	59	64	58	62	65	64	66	64	59	64	61	59	60
IF D	64	60	61	60	60	66	56	63	71	63	61	63	62	64	60	63	59	64	65	65	65	66	59	64	62	61	61
S Band																											
IF A	54	56	54	56	57	58	55	54	63	57	54	60	55	57	54	56	57	59	64	53	53	55	54	53	57	57	56
IF B	54	55	56	56	57	58	56	54	64	58	54	62	55	58	55	56	57	59	62	53	53	53	56	54	56	56	57
IF C	54	54	54	55	57	57	56	54	57	57	55	70	54	58	56	56	57	59	62	53	53	55	55	55	56	54	56
IF D	54	55	54	55	56	58	56	55	61	58	56	71	56	57	56	57	58	58	64	54	54	55	55	54	57	55	57
C Band																											
IF A	53	64	58	63	71	56	67	55	58	59	52	59	58	61	54	53	57	67	59	58	61	61	67	62	64	65	53
IF B	53	63	59	63	69	56	68	55	58	59	52	59	58	62	56	52	57	66	58	56	60	62	68	64	64	64	53
IF C	55	63	59	63	69	54	66	55	59	58	52	59	58	62	56	52	57	66	57	56	60	63	68	64	64	64	52
IF D	54	62	59	62	68	54	68	54	62	58	52	61	60	61	57	53	57	67	58	57	60	64	69	64	64	64	53
X Band																											
IF A	60	57	58	60	56	61	57	55	61	57	58	63	57	62	60	57	58	60	63	59	55	61	58	60	56	56	55
IF B	60	56	60	61	56	61	58	54	59	56	58	62	56	62	61	57	57	60	62	59	54	60	57	59	56	56	55
IF C	60	236	58	60	55	62	57	56	58	56	59	62	55	70	61	56	56	58	62	59	59	60	60	59	57	57	56
IF D	60	234	57	60	56	61	56	56	61	57	59	61	55	70	60	55	56	58	61	58	58	61	59	58	57	57	55
U Band																											
IF A	71	58	60	66	61	75	64	58	62	69	57	62	65	63	62	58	63	65	64	66	61	63	60	60	64	62	61
IF B	72	58	63	66	62	74	65	58	62	71	57	64	65	63	62	58	63	66	64	66	61	62	59	62	62	60	61
IF C	65	58	63	63	64	74	60	58	65	73	62	67	68	62	64	57	61	64	65	64	60	60	57	60	62	59	62
IF D	66	57	63	64	63	77	60	59	66	71	61	68	68	63	63	58	61	64	67	64	61	59	58	61	64	60	62
K Band																											
IF A	106	154	103	100	100	115	101	102	108	101	100	106	103	107	100	102	98	105	104	114	108	108	98	98	112	101	97
IF B	108	153	106	102	99	113	102	103	108	102	100	108	103	110	100	102	98	105	102	114	107	107	99	99	110	100	97
IF C	106	166	106	104	100	108	98	102	106	104	104	106	100	107	99	100	97	106	106	118	106	106	102	99	107	97	99
IF D	106	166	104	103	98	112	96	103	112	102	106	105	104	109	100	101	98	106	108	119	109	106	98	98	108	98	101
A Band																											
IF A	113	100	100	104	160	106	132	94	104	107	93	99	104	105	104	102	102	104	106	108	105	94	104	109	100	104	95
IF B	112	98	102	103	159	105	132	94	106	110	94	99	102	105	106	102	101	103	105	108	102	93	106	110	100	100	96
IF C	115	101	1581	103	106	100	149	96	102	106	92	96	103	99	104	100	102	101	105	106	104	94	106	114	101	103	94
IF D	114	100	1577	105	105	106	149	97	106	108	93	99	104	100	104	102	102	100	106	104	104	95	104	112	100	104	96
Q Band																											
IF A	204	125	166	177	142	178	122	134	507	130	130	133	132	155	135	142	166	135	156	286	166	141	137	506	147	151	752
IF B	208	124	170	178	140	176	126	137	505	133	132	137	133	156	136	142	164	134	158	282	166	141	141	514	146	150	762
IF C	210	126	168	670	142	172	132	136	484	130	138	138	131	156	134	141	162	138	150	286	168	143	140	163	146	158	750
IF D	204	125	168	640	138	177	134	136	511	132	136	138	134	159	135	144	164	139	156	290	168	146	138	164	144	158	762

Figure 1: Example operators' stress test report. This page shows uncalibrated gains for the afternoon test on September 17, 2014

SEFD is the system equivalent flux density, which is the power density in Janskys necessary to double the system temperature.

3 Stress Test Sky Frequencies

The stress test examines one 128MHz-wide subband at each receiver band. This subband is chosen to be as free as possible from RFI contamination, to ensure calibratable data. Table 1 lists these frequencies, as well as the F317 monitor and M301 band designation corresponding to each. These are useful for follow-up monitor data archive searches.

Table 1: Sky frequencies and monitor/control access points per receiver band

Band	Fsky GHz	F317	M301 Observe_Band_Mon
L	1388- 1516	2-FE1	6
S	3020 – 3148	2- FE2	7
C	4832 – 4960	1- FE1	8
X	8332 – 8460	2- FE3	5
U	14936 – 15064	2- FE4	4
K	24372 – 24500	1- FE2	3
A	33432 – 33560	1- FE3	2
Q	40936 - 41064	1- FE4	1

4 The Range of Values

Table 2 shows the alert limits placed on system temperature and Uncalibrated gain. Values outside of these limits are flagged by the operators' report generator. In May 2014 we looked at four months of data, spanning November 2013 to March 2014, to assess whether these limits realistically reflected the state of the present system, or required changing. The four month period was chosen to minimize the effect of weather on the system temperature measurements. Histograms of the distributions of uncalibrated gain and system temperature values for this four-month period, along with proposed changes to the limits, are shown in the figures in Appendix B.

Table 2: Limits by receiver band on uncalibrated gain and Tsys

Band	Uncalibrated gain Limits	T_{sys} Limits (K)	Project Book T_{sys} Requirement (K)
'L'	65 to 96	25 to 40	26
'S'	55 to 78	25 to 35	26
'C'	55 to 72	25 to 35	26
'X'	55 to 72	25 to 35	30
'U'	50 to 72	25 to 35	37
'K'	70 to 96	40 to 60	59
'A'	75 to 102	45 to 75	53
'Q'	100 to 144	65 to 90	74

5 Interpretation of Stress Test Results

If T_{sys} is below the lower limit, this is taken to be an unphysical result, and is most likely due to the noise diode calibration temperature (Tcal) file not accurately reflecting the additional noise power added by the receiver's calibration noise diode.

Table 3 shows combinations of out-of-range conditions for uncalibrated gain, T_{SYS}, and calibrated gain and the possible origins of these conditions.

Table 3: Stress Test troubleshooting decision table

Uncalibrated gain	T_{SYS}	Calibrated gain	Possible cause
HIGH	NORMAL	NORMAL	Optics LO jitter
HIGH	HIGH	NORMAL	Warm receiver
NORMAL	HIGH	HIGH	Bad switched power/noise diode Tcal file error
HIGH	HIGH	HIGH	Oscillating front-end amplifier
HIGH	NORMAL	HIGH	Pointing, optics, LO jitter
NORMAL	HIGH	HIGH	Gain compression

If a parameter (uncalibrated gain, T_{SYS}) is bad for all receiver bands on a particular antenna, this could indicate an LOIF or back-end problem, particularly if it does not affect all IFs.

If uncalibrated gain increases with increasing sky frequency, this could indicate either a pointing or optics problem, or local oscillator jitter, and is generally indicative of low antenna efficiency.

If either T_{SYS} or uncalibrated gain is elevated for all antennas for a given band, this is likely due to atmospheric instability, wind, or humidity. Uncalibrated gain and T_{SYS} are often high for Ku-band and higher frequencies during the summer monsoon months, particularly for the afternoon stress test. The early morning stress test is often a more reliable indicator of system health during the summer.

In addition, a web-based graphical plotting tool Stress Test Data Viewer allows plotting of any quantity for one antenna, for any combination of IFs, over a user-specified time range. This tool is accessible at http://mccctest.evla.nrao.edu:8100/stressDataViewer.html Figure 2 shows a screen capture of the web-based tool.

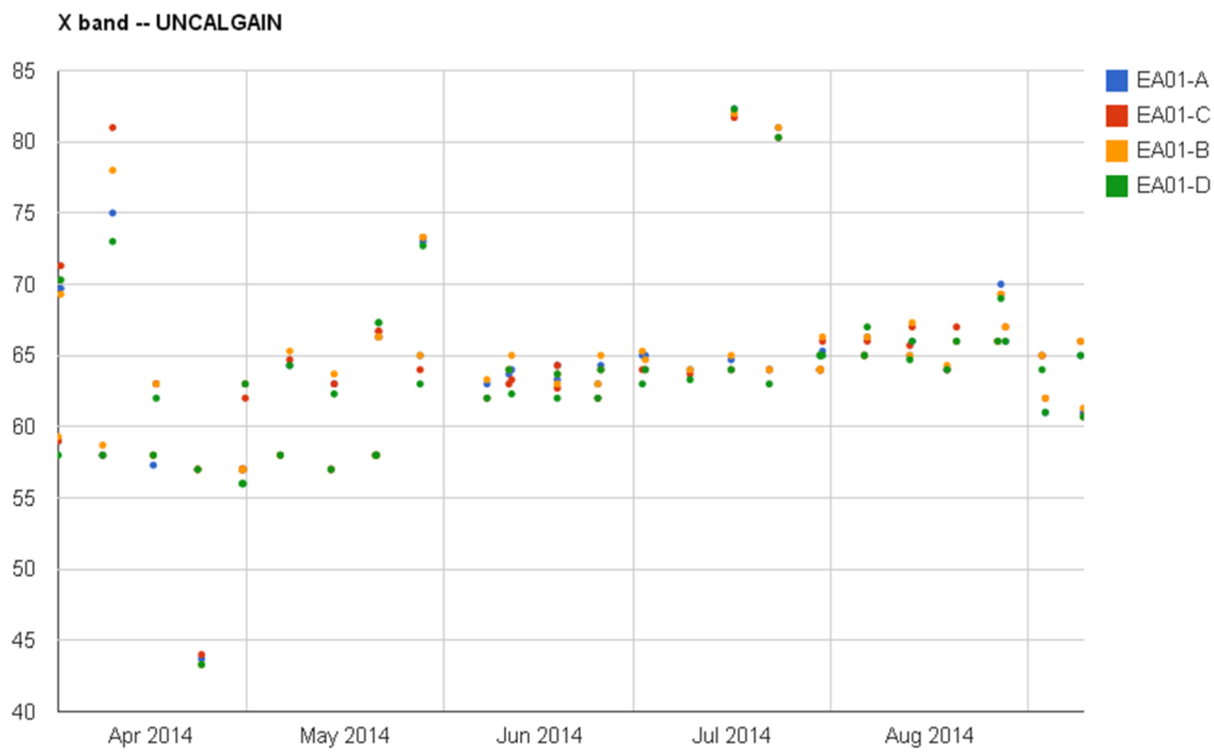


Figure 2: Screen capture of Stress Test Data Viewer, showing X-band uncalibrated gain, antenna ea01, all IFs, for the period April 2014 – September 2014.

6 Acknowledgements

This memo represents the combined effort of the entire "Stress Test Crew", consisting of the authors, Eric Chavez, Drew Medlin, Jim Jackson, Dave Parker, and Denis Urbain.

Appendix A: EVLA Project Book Specifications

The following are taken directly from the EVLA Project Book, and are included in this appendix for convenience only. These tables are not meant to take the place of the official Project Book documents, which should be referred to for the most recent requirements.

On-Axis Efficiency (EVLA Project Book Section 2.2.2.1)

This includes the effects of aperture blockage, surface roughness, spillover, illumination taper, feed alignment, diffraction losses, and VSWR losses for both the feed and LNA. The values given are for mid-band.

Table 4: EVLA Project Book efficiency requirements

Band	Freq. Range (GHz)	Required	Target
L	1.2 – 2.0	0.45	0.50
S	2.0 – 4.0	0.62	0.68
C	4.0 – 8.0	0.60	0.66
X	8.0 – 12.0	0.56	0.61
Ku (‘U’)	12.0 – 18.0	0.54	0.59
K	18.0 – 26.5	0.51	0.56

System Temperature and Sensitivity (EVLA Project Book 2.2.3.1)

The requirements for each band for the total system temperature are listed below. The listed values apply to the middle 50% of each band, include atmospheric absorption and emission, and are referenced above the atmosphere. See Table 3-2 for a breakdown of the contributions.

Table 5: EVLA Project Book T_{SYS} requirements

Band (GHz)	T_{SYS}	Comments
1 – 2	26	
2 – 4	26	
4 – 8	26	
8 – 12	30	
12 – 18	37	
18 – 26.5	59	Under optimum conditions*
26.5 – 40	53	Under optimum conditions*
40 – 50 (low end)	74	Under optimum conditions*
40 – 50 (high end)	116	Under optimum conditions*

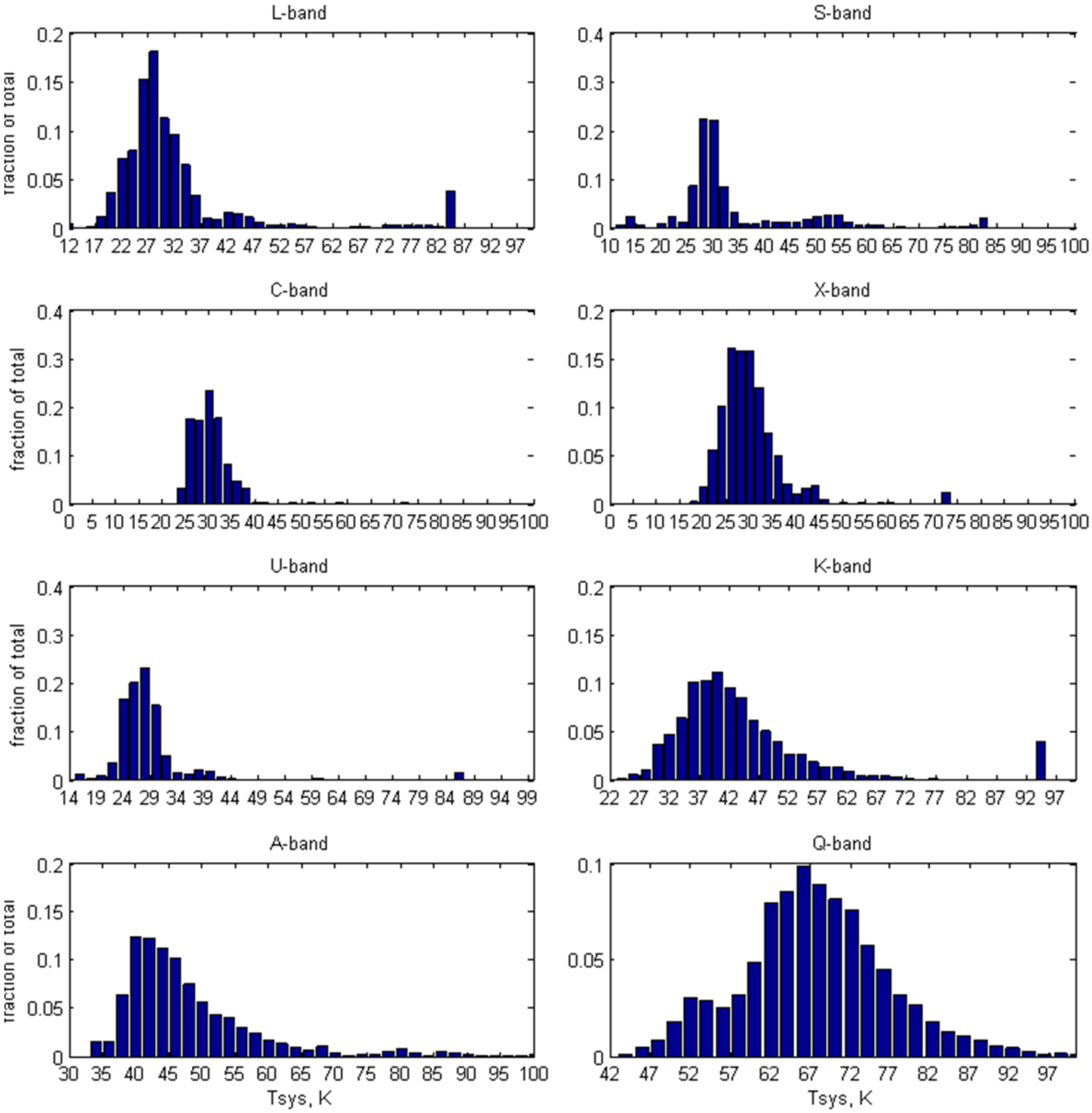
These requirements, when combined with the antenna efficiency requirements listed in 2.2.2.1, give the following system sensitivity requirements. These supersede both the efficiency and system temperature requirements.

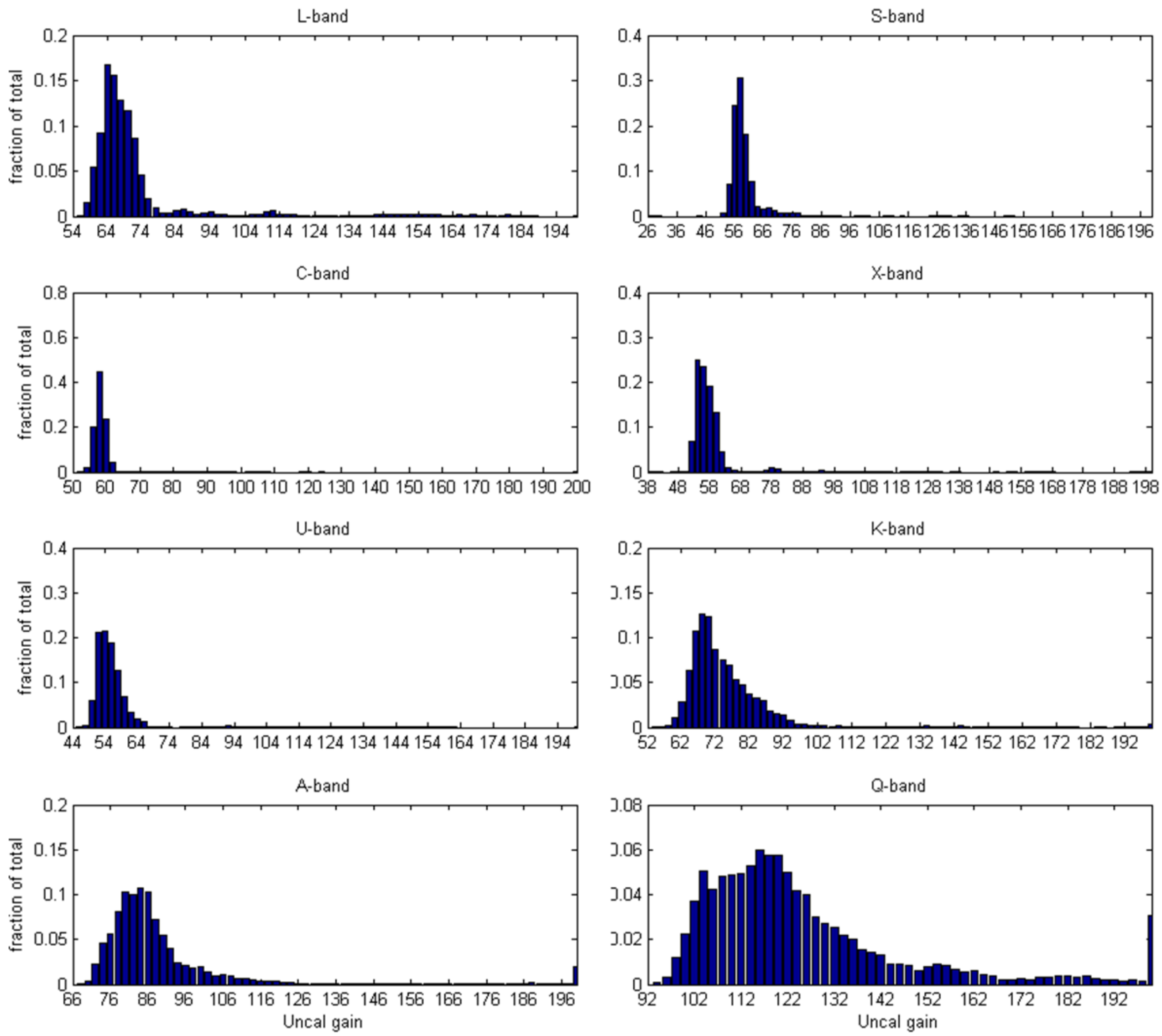
Table 6: EVLA Project Book SEFD requirements

Band (GHz)	A_e/T_{SYS} (m^2/K)	SEFD (Jy)
1 – 2	8.2	325
2 – 4	11.3	235
4 – 8	10.9	245
8 – 12	8.9	300
12 – 18	7.0	385
18 – 26.5	4.1	650
26.5 – 40	3.5	760
40 – 50 (@ 43)	2.4	1220
40 – 50 (@ 49)	1.0	2760

Required: Degradation of receiver temperature within any band with respect to the mean defined in the central 50% is to be by less than 3dB at any frequency, by less than 1dB over the inner 85% of each band, and by less than 2 dB over 95% of the band.

7 Appendix B: Distributions of Tsys and Uncalibrated Gain




L-band
S-band
C-band
X-band
U-band
K-band
A-band
Q-band
fraction of total
Uncal gain