EVLA Front-End CDR

Low Noise Amplifier Procurement

Welcome to the CDL! (What I expected)

What I Found
(The “old” CDL)

The New NTC / CDL (Since early 2004)

10 year lease

What Does the CDL Need to Provide?

- Thanks to Bob Hayward's clear forecast we know that the requirement is basically to supply 80 Amplifiers per year for 2007 thru 2010.

- If we're able to do that then 35-40 Amps per year, in the later years, (2011-2014) is easy.

LNA Forecast for EVLA Rx's

2	- Qty Required (Light Blue or Yellow)
2	- Full Qty Delivered
2	- Partial Qty Delivered
2	- Awaiting Cryo Upgrade

Antenna Serial Number	Date LNA's Required	Date of Ant Commission	L-Band		S-Band	C-Band	X-Band	Ku-Band	K- Band		Ka-Band	Q- Band		Amps per Year
			LN Bal	HP Bal	Bal Amp				Upgrade	New		Upgrade	New	
Antenna 14 (Az Bearing)	All In-House	Jan 31, 2005	2	2	-	2	-	-	-	0	-	-	0	
Antenna 16 (Az Bearing)	Feb 27, 2005	Apr 28, 2005	2	2	-	2	-	-	2	-	-	-	0	14
Antenna 13 (retrofit)	May 22, 2005	Jul 21, 2005	-	-	-	2	-	-	-	0	2	2	-	
Antenna 18 (Az Bearing)	Jul 1, 2005	Aug 30, 2005	2	2	-	2	-	-	-	2	-	-	2	16
Antenna 24	Jan 28, 2006	Mar 29, 2006	2	2	-	2	-	-	-	2	-	2	-	
Antenna 26 (Az Bearing)	Aug 19, 2006	Jun 23, 2006	2	2	2	2	-	-	-	0	-	-	2	
Antenna 23	Apr 24, 2006	Oct 18, 2006	2	2	-	2	-	-	-	2	*2*	2	-	32
Antenna 17	Dec 3, 2006	Feb 1, 2007	2	2	-	2	-	-	-	2	2	2	-	
Antenna 1	Feb 3, 2007	Apr 4, 2007	2	2	2	2	-	2	2	-	4	2	-	
Antenna 19	Apr 1, 2007	May 31, 2007	2	2	-	2	2	-	-	2	2	2	-	
Antenna 21	May 28, 2007	Jul 27, 2007	2	2	2	2	-	-	2	-	4	2	-	
Antenna 10 (Az Bearing)	Aug 24, 2007	Oct 23, 2007	2	2	-	2	-	-	-	2	2	2	-	72
Antenna 11	Oct 21, 2008	Dec 20, 2008	2	2	2	2	-	-	2	-	4	-	2	
Antenna 25	Jan 6, 2008	Mar 6, 2008	2	2	-	2	-	-	2	-	2	-	2	
Antenna 2	Mar 3, 2008	May 2, 2008	2	2	2	2	-	-	2	-	4	2	-	
Antenna 5	May 1, 2008	Jun 30, 2008	2	2	-	2	-	-	-	2	2	2	-	
Antenna 9	Jun 27, 2008	Aug 26, 2008	2	2	2	2	-	-	-	2	4	-	0	
Antenna 20 (Az Bearing)	Sep 21, 2008	Nov 20, 2008	2	2	-	2	-	-	2	-	2	-	2	82
Antenna 3	Dec 8, 2008	Feb 6, 2009	2	2	2	2	-	-	2	-	2	-	2	
Antenna 7	Feb 6, 2009	Apr 7, 2009	2	2	-	2	-	2	-	2	2	2	-	
Antenna 15	Apr 4, 2009	Jun 3, 2009	2	2	2	2	-	-	2	-	2	2	-	
Antenna 4	May 31, 2009	Jul 30, 2009	2	2	-	2	-	2	2	-	2	-	2	
Antenna 8	Jul 27, 2009	Sep 25, 2009	2	2	2	2	-	-	2	-	2	2	-	
Antenna 27	Sep 24, 2009	Nov 23, 2009	2	2	-	2	-	-	-	0	2	-	2	80
Antenna 28	Dec 7, 2009	Feb 5, 2010	2	2	2	2	-	2	2	-	2	2	-	
Antenna 6	Feb 8, 2010	Apr 9, 2010	2	2	-	2	-	-	2	-	2	-	0	
Antenna 22	Apr 5, 2010	Jun 4, 2010	2	2	2	2	-	2	-	0	2	2	-	
Antenna 12	Jul 24, 2010	Sep 22, 2010	2	2	-	2	-	-	-	0	2	2	-	
Retrofit Earlier Antennas	Aug 1, 2010	-	6	6	4	4	-	2	2	-	4	-	2	80
Retrofit Earlier Antennas	Jan 1, 2011	-	-	-	6	-	6	6	-	-	-	2	-	
Retrofit Earlier Antennas	Aug 1, 2011	-	-	-	6	-	6	6	-	-	-	1	-	39
Retrofit Earlier Antennas	Jan 1, 2012	-	-	-	6	-	6	6	-	-	-	-	-	
Retrofit Earlier Antennas	Aug 1, 2012	-	-	-	6	-	6	6	-	-	-	-	-	36
Retrofit Earlier Antennas					5		6	6						
Retrofit Earlier Antennas					5		6	6						34
Retrofit Earlier Antennas							11	6						
Retrofit Earlier Antennas							11	6						34
Retrofit Earlier Antennas														
Retrofit Earlier Antennas														0
Spare LNA's	Anytime	-	6	6	6	6	6	6	-	6	6		6	54
Sub-Totals			66	66					28	24		35	24	
			132		66	66	66	66	52		66	59		573

Amplifiers per year

Year	New Builds	Upgrades
2006	24	8
2007	58	14
2008	70	12
2009	66	14
2010	68	12
2011 thru 2014	35-40/year	na

The CDL "Track Record" with Amplifiers

- Hundreds of LNAs produced over the past 20+ years.
- VLA, VLBA, GBT, and many outside observatories use CDL LNAs
- The WMAP experience
- Near 100% reliability for post-WMAP units, no clear MTBF since they seldom fail, so no statistics
- Failures that do happen appear in early testing (typically the first cool down) and are corrected.

CDL Resources for Amplifier Production

- Design talent – Marian Pospieszalski, Richard Bradley (low frequencies)
- Production talent – Bill Lakatosh, Mitch Wharam
  - Todd Boyd, Mike Lambeth, or a “to be hired”
- Manufacturing capability
  - Machine shop, CNCs
  - Plating shop, new in 2004
  - Electronics assembly, wirebonding
  - Testing, 8510s, ADIOS, new systems

How Do We Build an Amplifier?

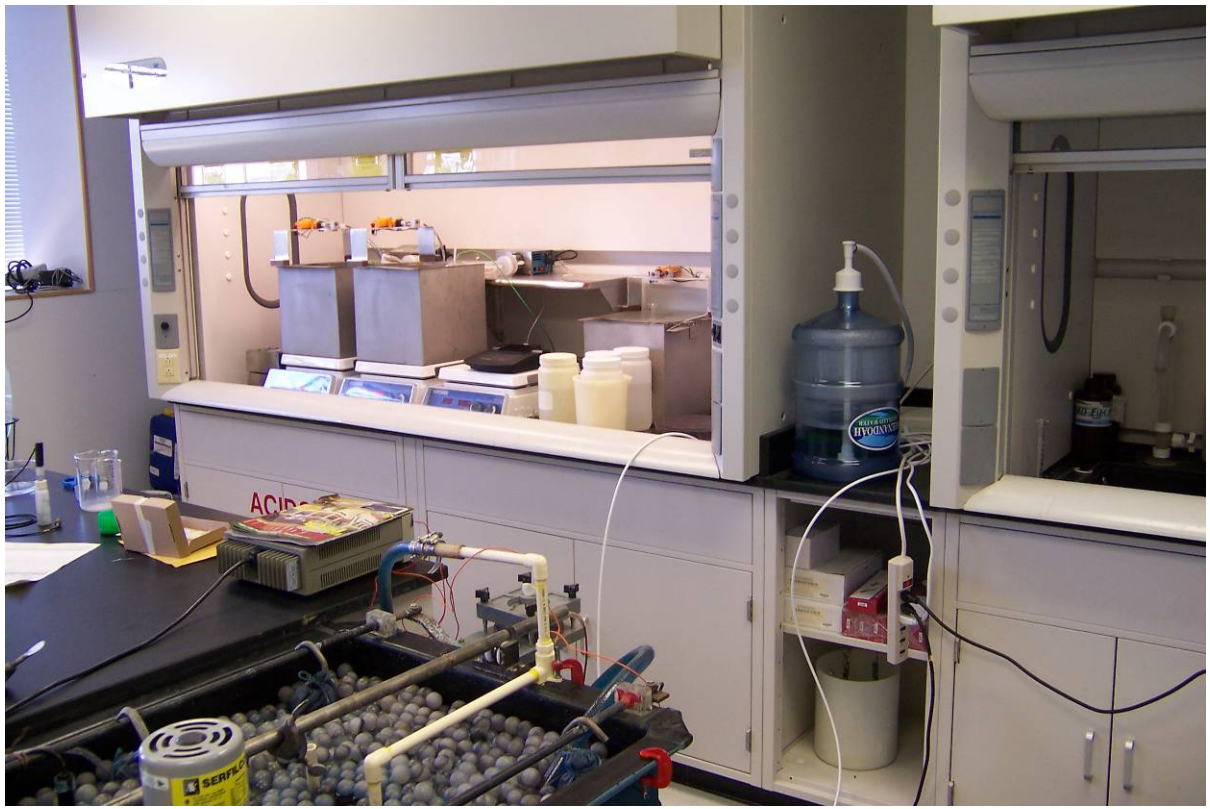
- Buy parts (ugghhh, it used to be so easy)
- Machine the chassis ---- 8 hours
- Prep and plate chassis ---- 3 hours
- Assemble ---- 3 to 4 per month per Tech
- Test and Document ---- 4 to 8 hours
- Ship It!!!

CDL Machine Shop
40% non - ALMA

$150,000
ALMA Precision

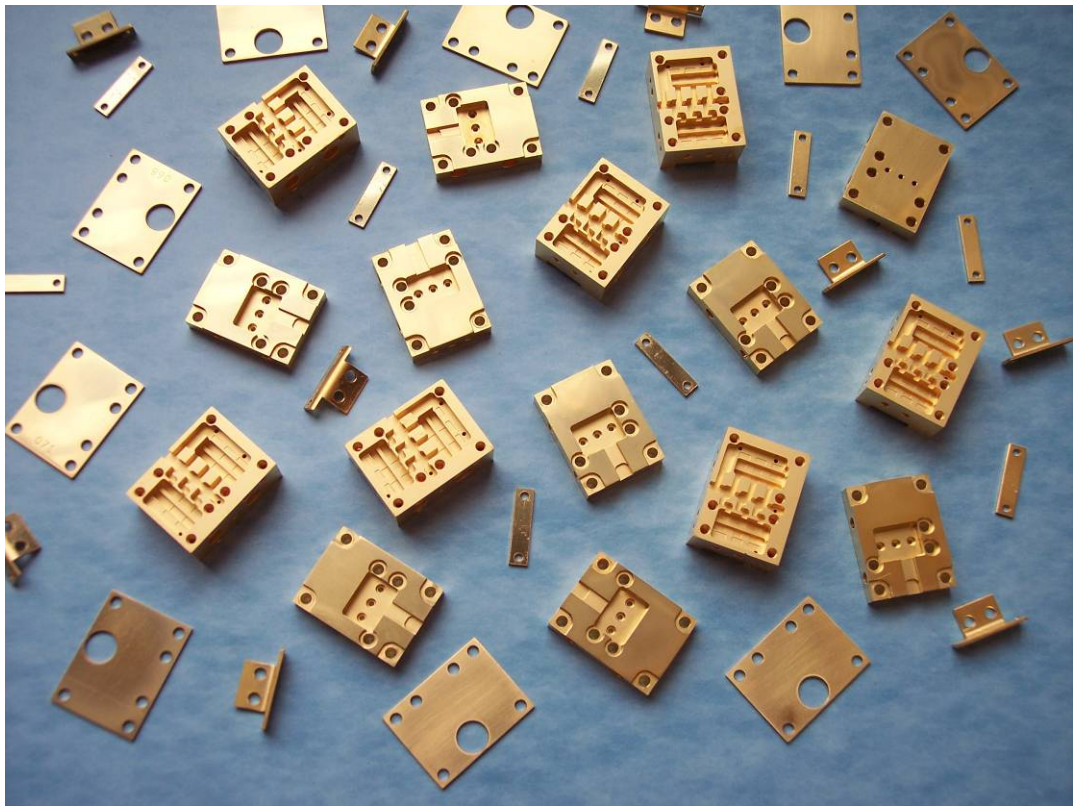
Milltronics Amplifier Chassis

Chemistry / Plating Lab



Gold Baths

ALMA IF Amp Chassis Freshly Plated



K-Connector Plates

Copper Electroforming Phase Shifter

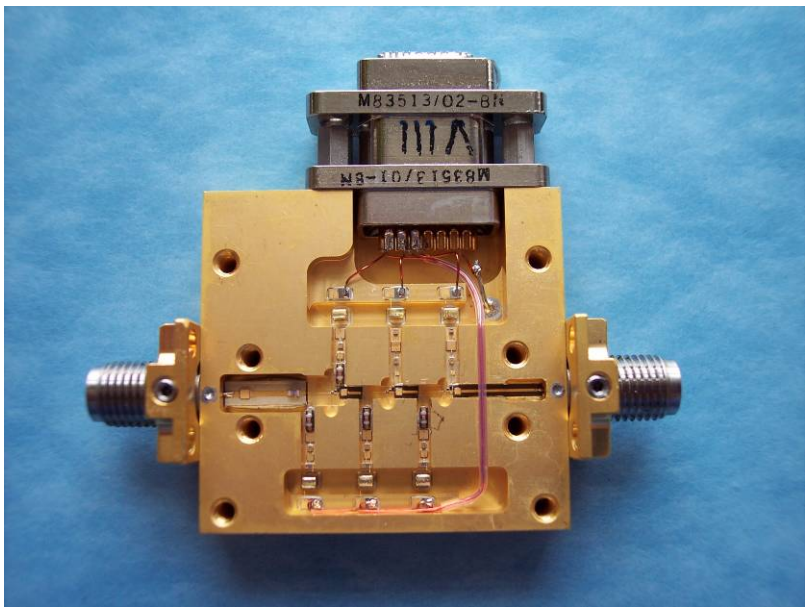
Amplifier Assembly Two Techs = 80 LNAs/year

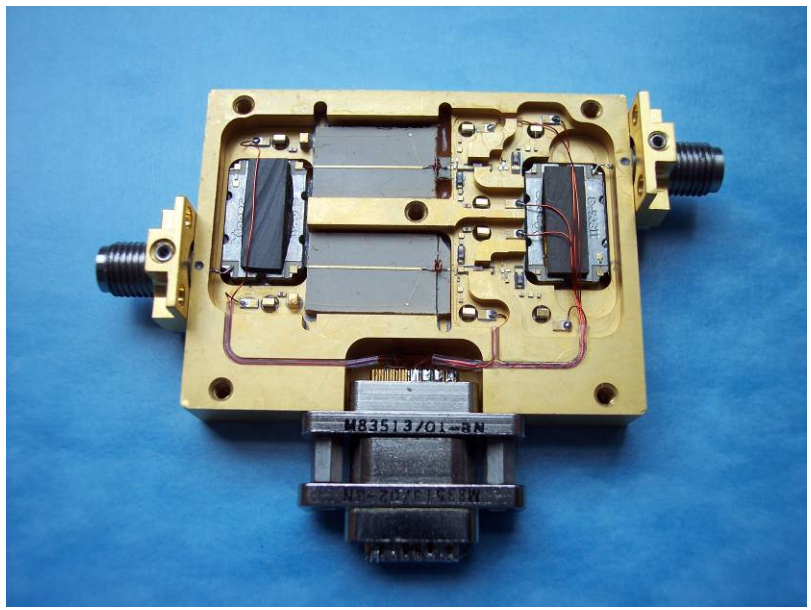
Wirebonding

Older Bonder
Two bonders available

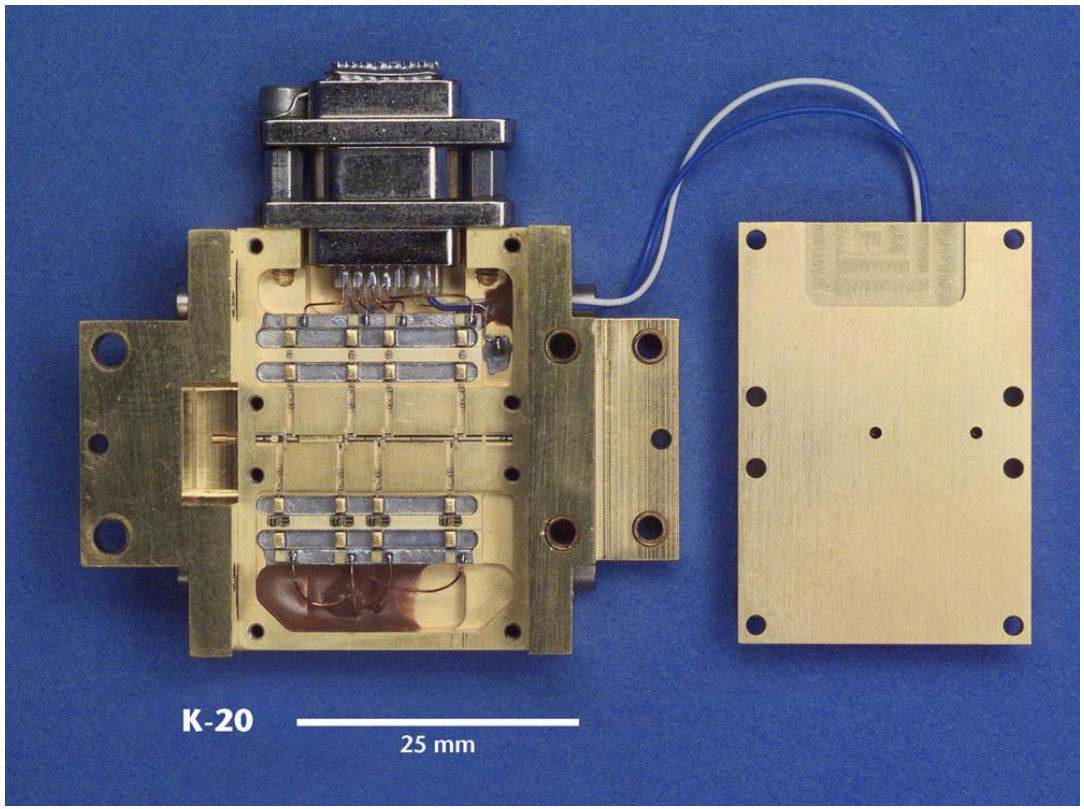
Assembly Area 2

Single ended - Balanced





K-band LNA (WMAP)



ADIOS Lives!

Band Specifics
Coaxial Amps

- L- LNA — in production, no issues
- L- HP — in production, no issues
- 2-4 GHz (S) — in production, FHX-45 vs C3
- 4-8 GHz (C) — in production, no issues
- 4-12 GHz (X) — in production, no issues
  - 8-12 version — designed, use if 4-8 gain not desired
- 8-18 GHz (Ku) — in production, no issues
  - 12-18 version — designed, use if 8-12 gain not desired

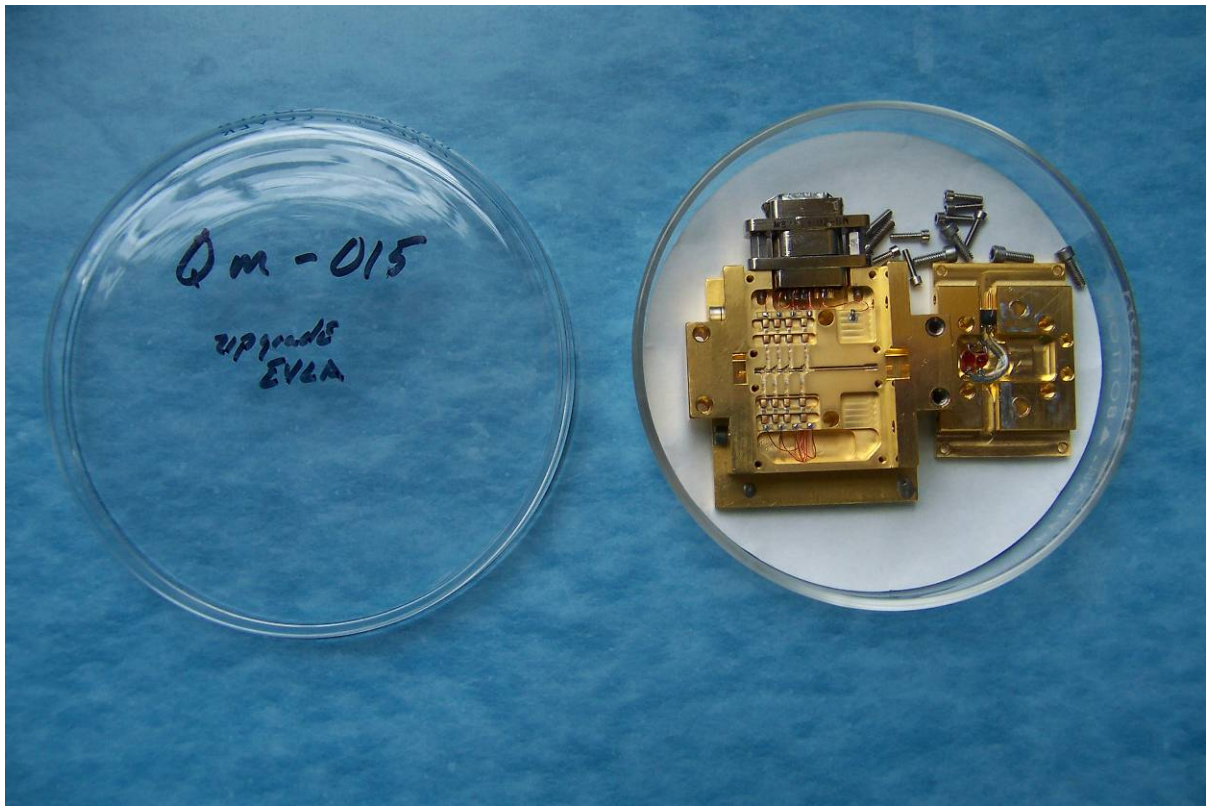
Waveguide Amps

- 18-26 GHz (K) in production, no issues
- 26-40 GHz (Ka) in production, no issues
- 40-50 GHz (Q) in production, no issues

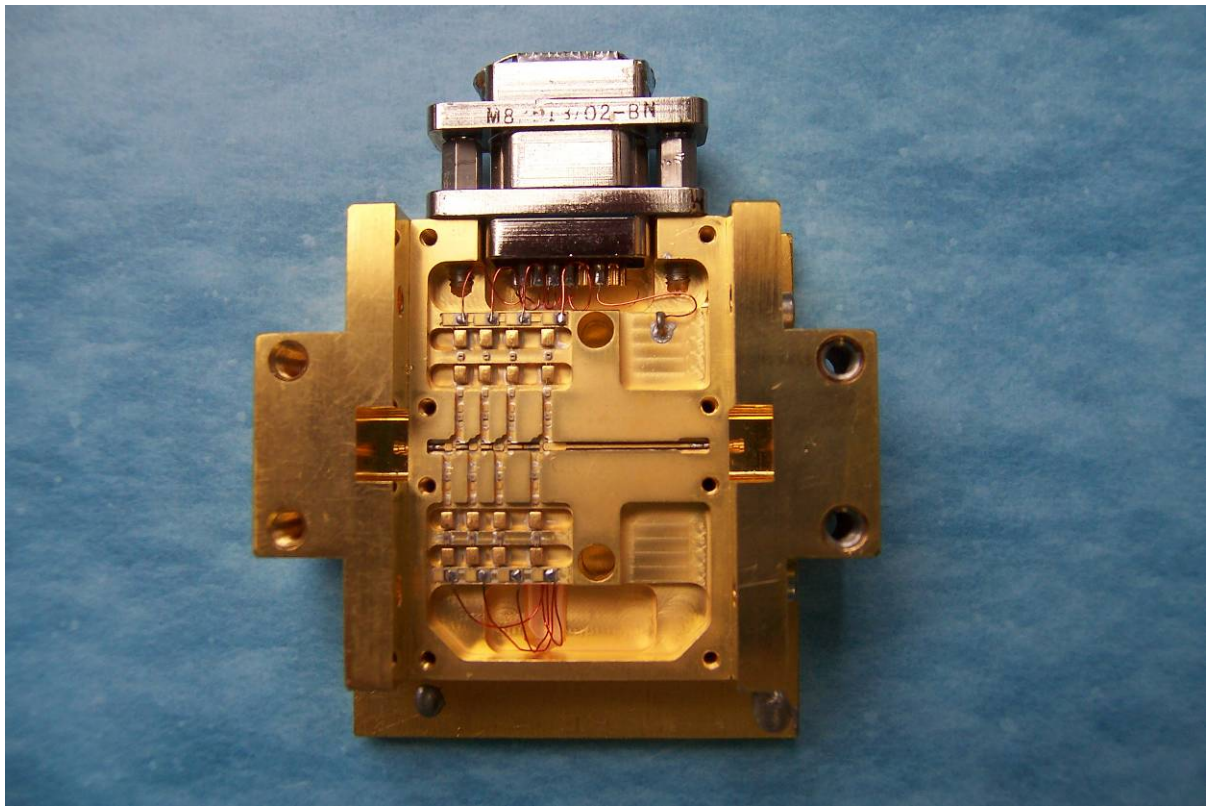
- Both 18-26 and 26-40 GHz designs will be improved for gain flatness.

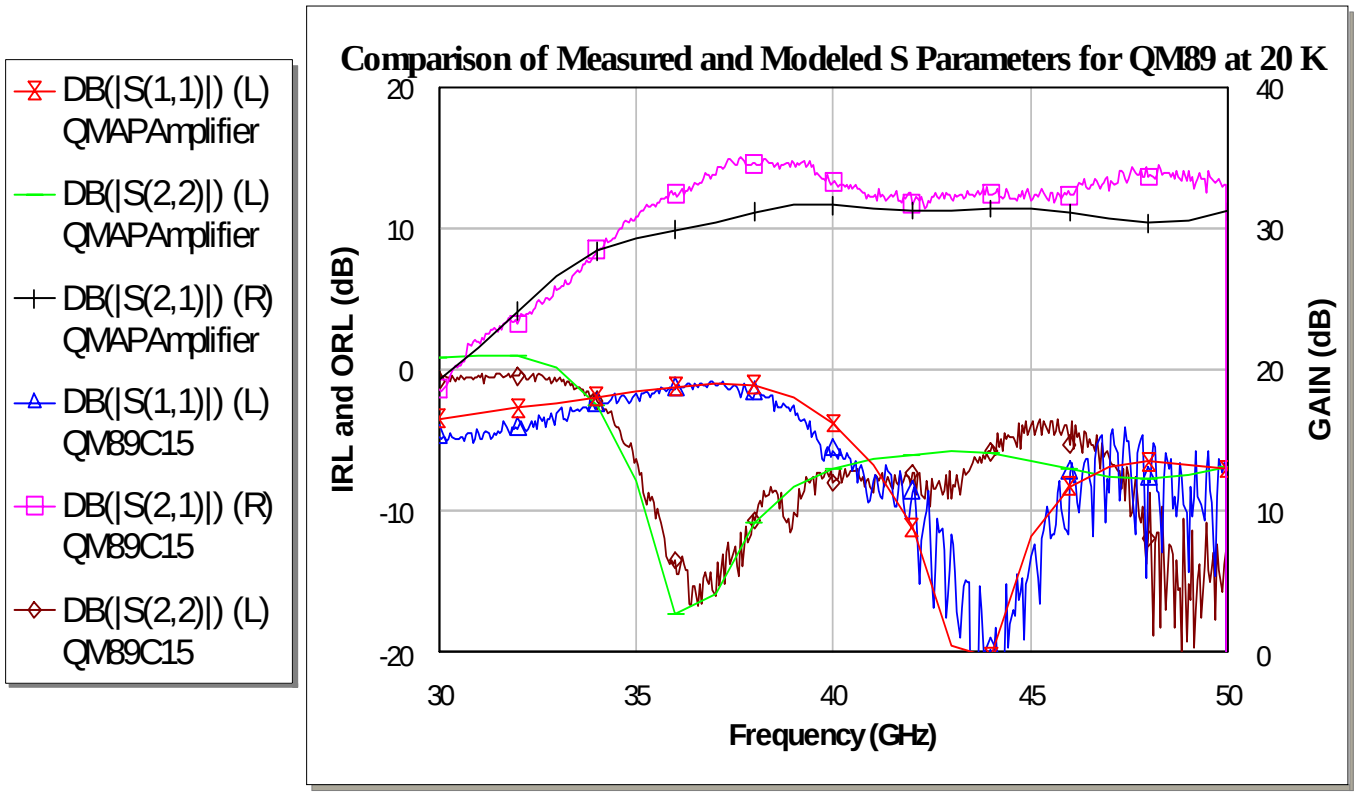
- Commercial components and vendors are all proven
- No device availability issues

Q-band Upgrade



Q-band Upgrade



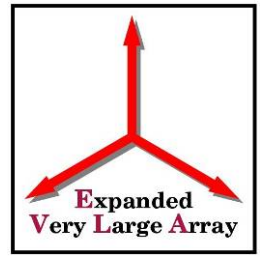

Comparison of Measured and Modeled S Parameters for QM89 at 20 K
DB(|S(1,1)|) (L) QMAPAmplifier
DB(|S(2,2)|) (L) QMAPAmplifier
DB(|S(2,1)|) (R) QMAPAmplifier
DB(|S(1,1)|) (L) QM89C15
DB(|S(2,1)|) (R) QM89C15
DB(|S(2,2)|) (L) QM89C15
IRL and ORL (dB)
GAIN (dB)
Frequency (GHz)
20
10
0
-10
-20
40
30
20
10
0
30
35
40
45
50

Fallbacks??

- Machining
  - J&E already doing ALMA mixers
- Plating
  - Alexandria Metal Finishers, cost 10-15X
- Assembly
  - ACC? Difficult experience for ALMA, they might be OK for bias components, in a pinch
- Testing
  - In house only

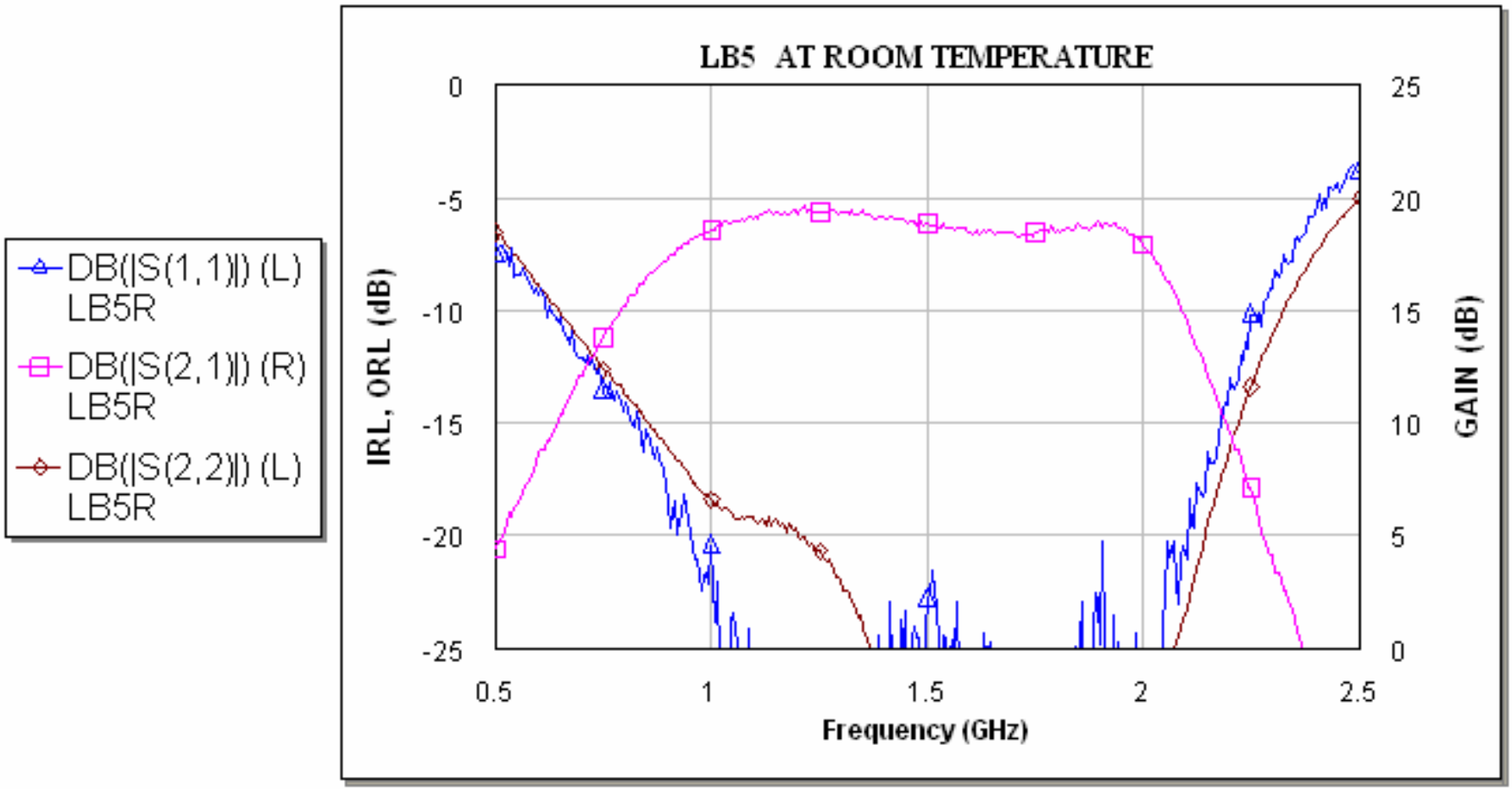
End of Presentation

Spare slides below

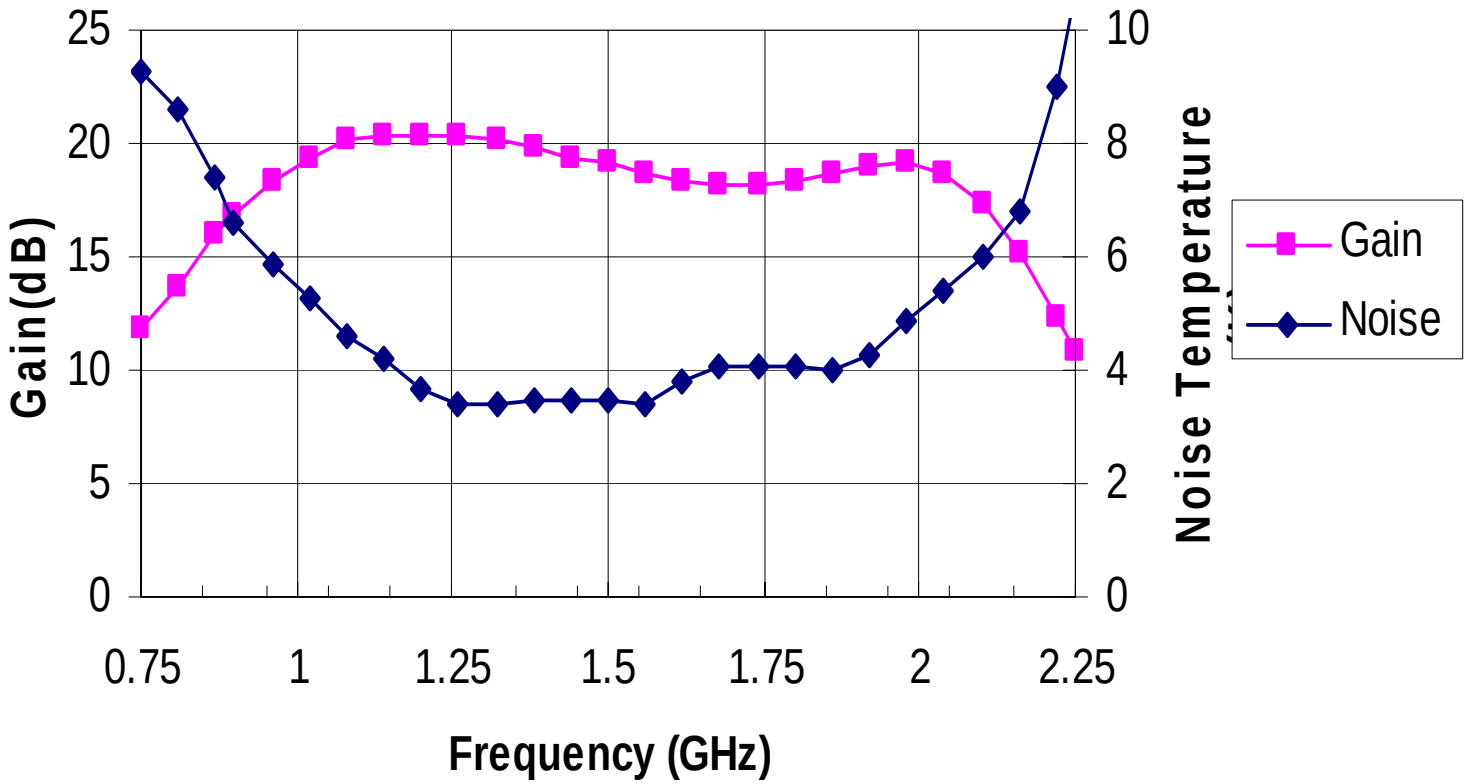


Backup Slides

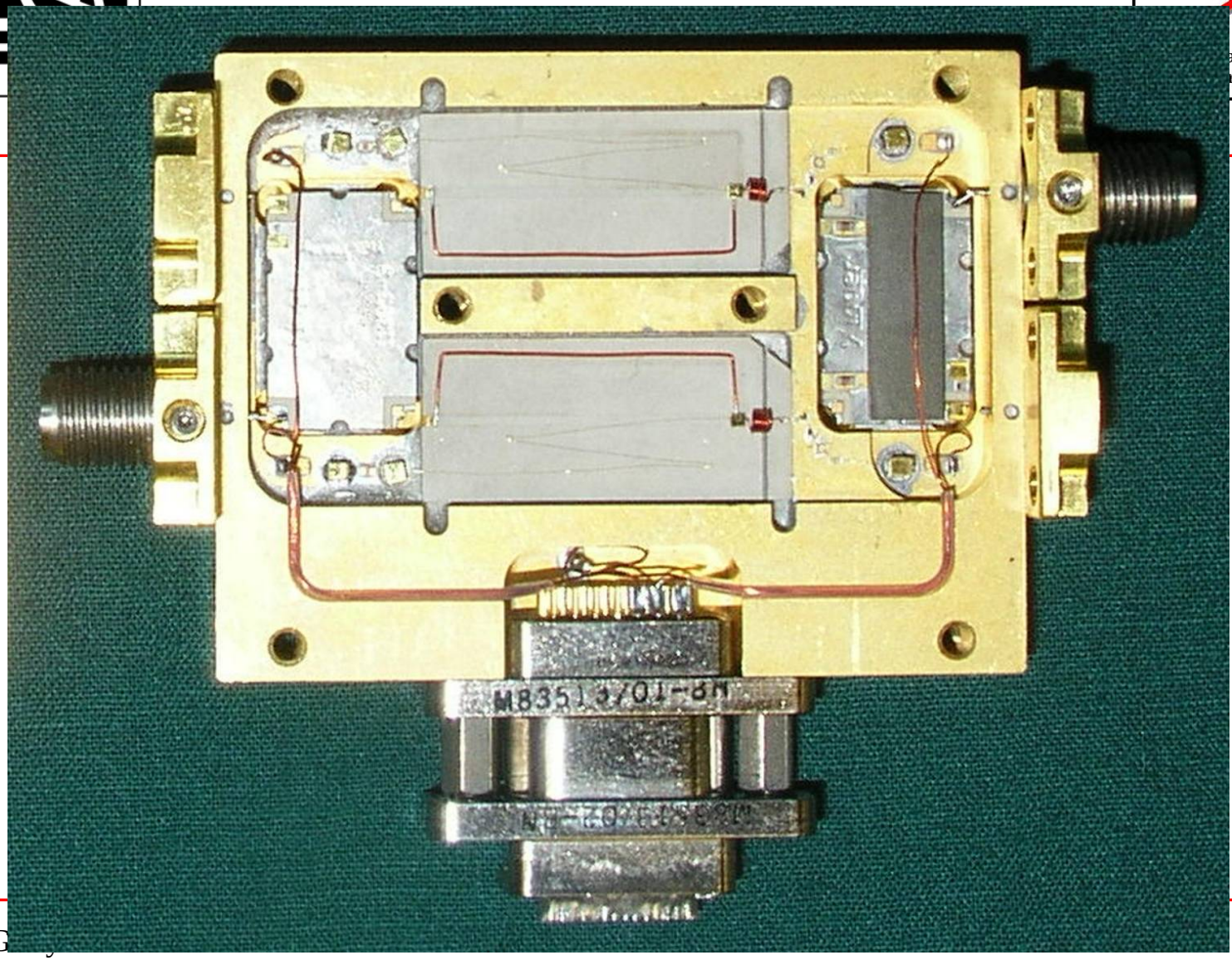
Bubble Trouble

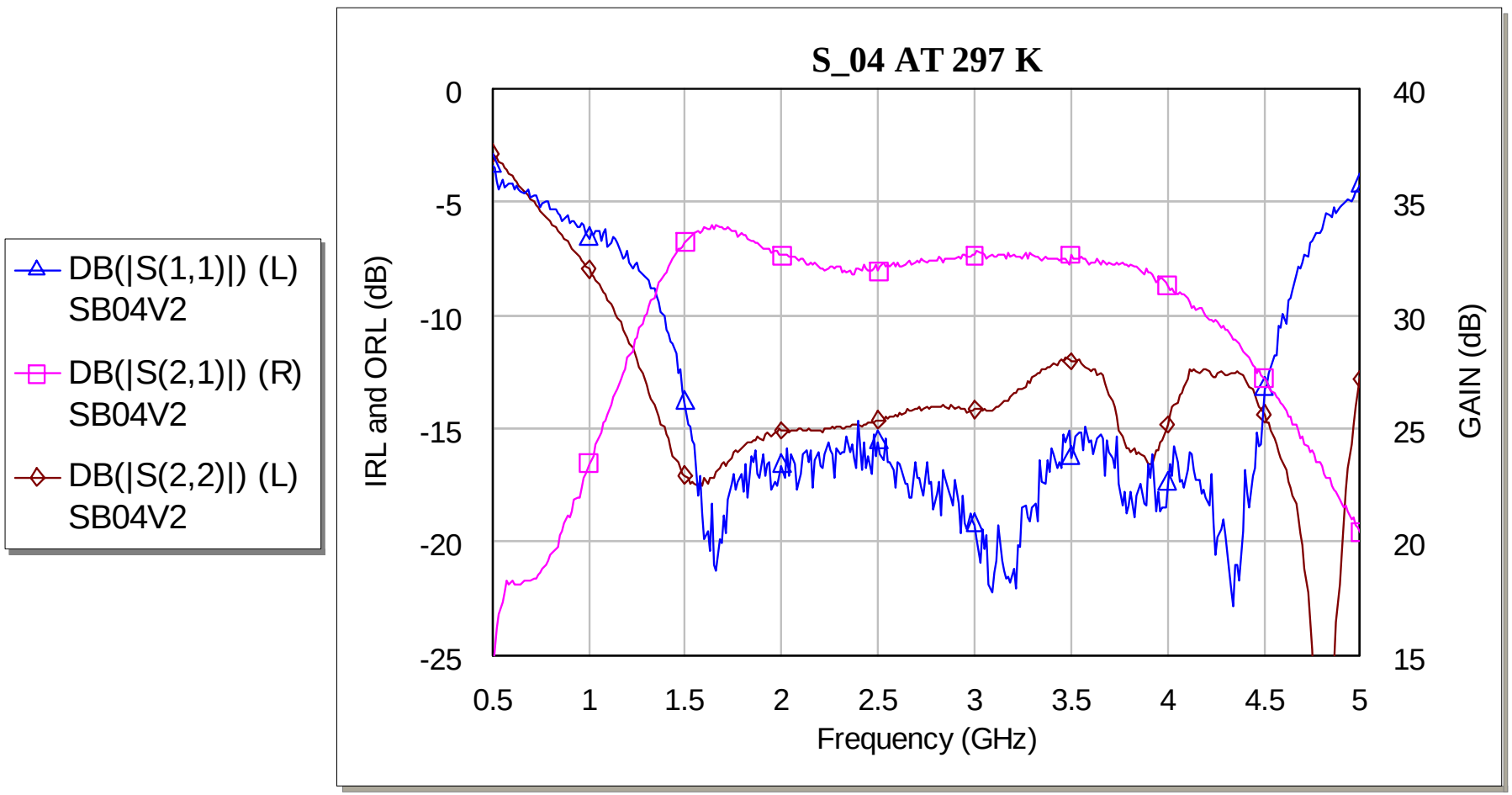

LB5 AT ROOM TEMPERATURE
DB(|S(1,1)|) (L) LB5R
DB(|S(2,1)|) (R) LB5R
DB(|S(2,2)|) (L) LB5R
IRL, ORL (dB)
GAIN (dB)
Frequency (GHz)
0
-5
-10
-15
-20
-25
25
20
15
10
5
0
0.5
1
1.5
2
2.5

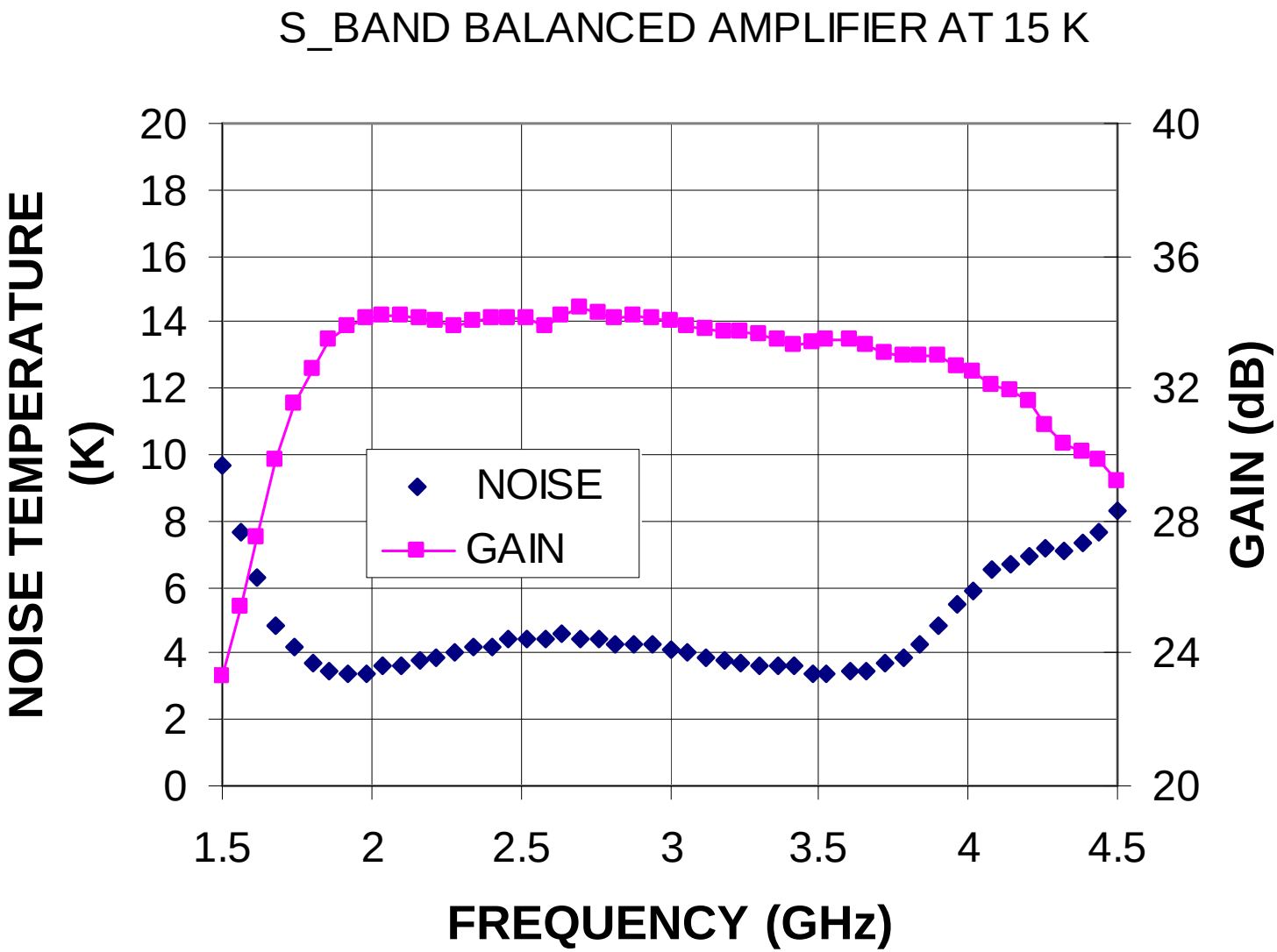
L-Band Balanced Amplifier at Ta=15 K



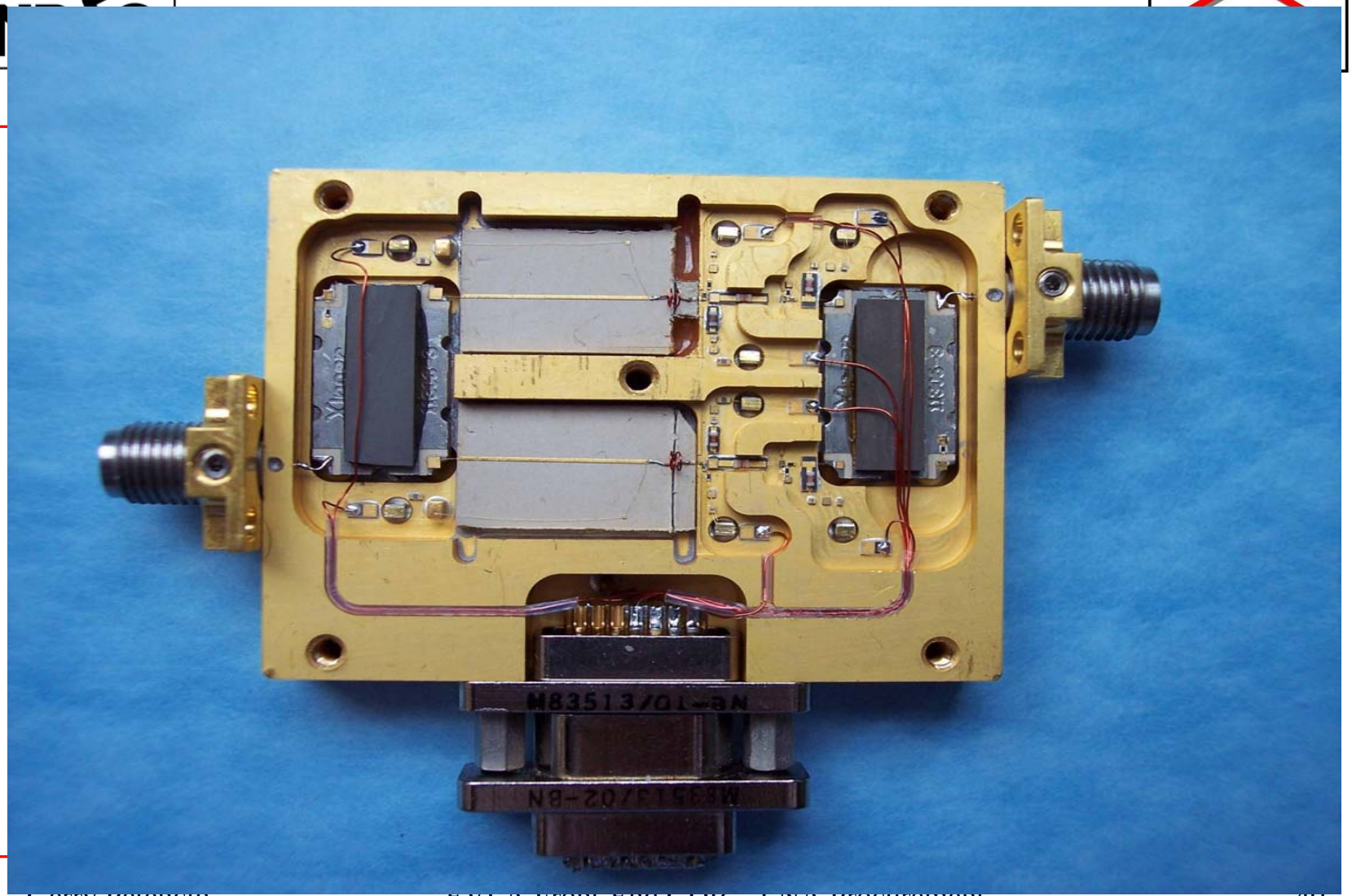
Balanced L-band Low

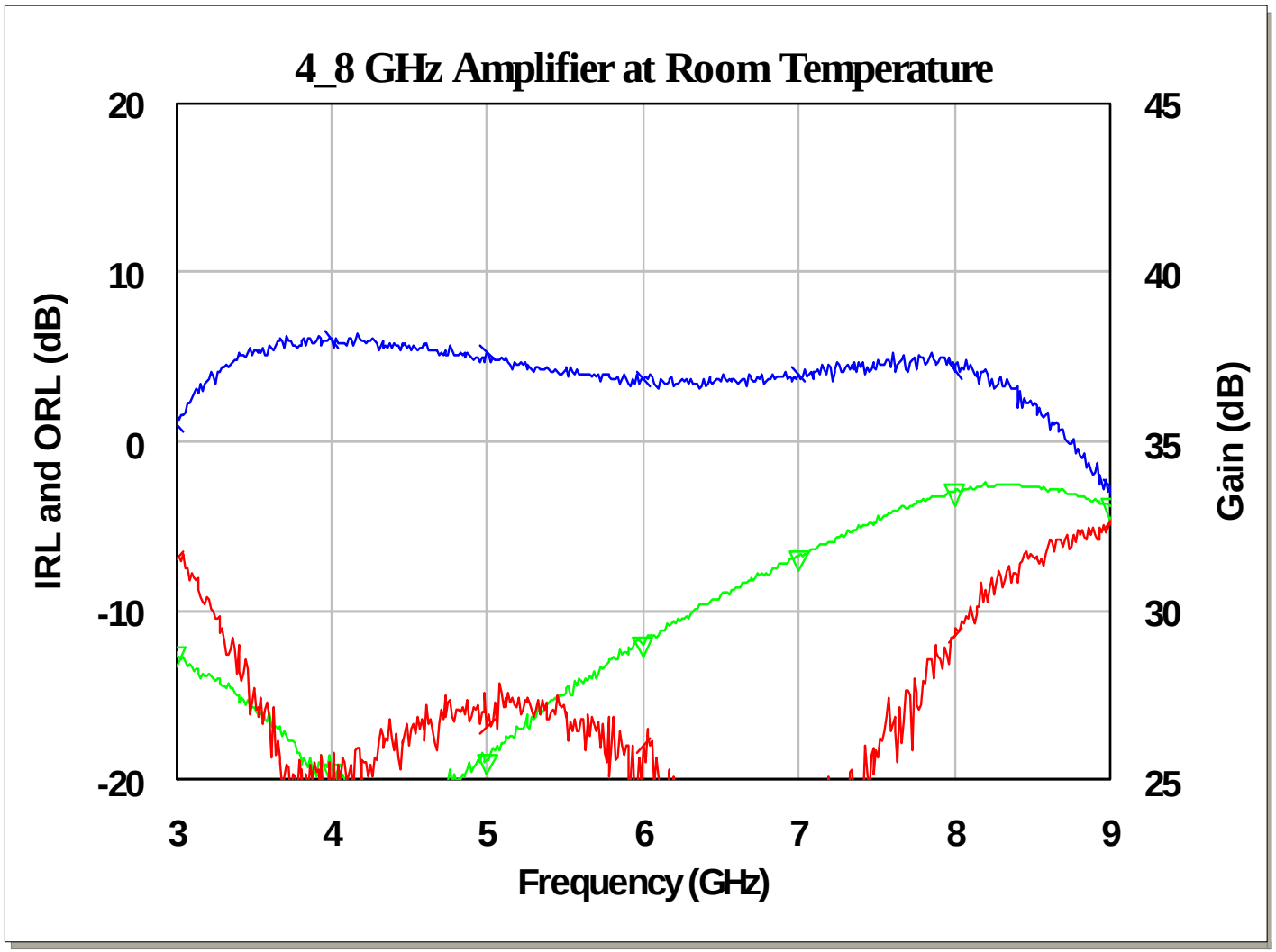


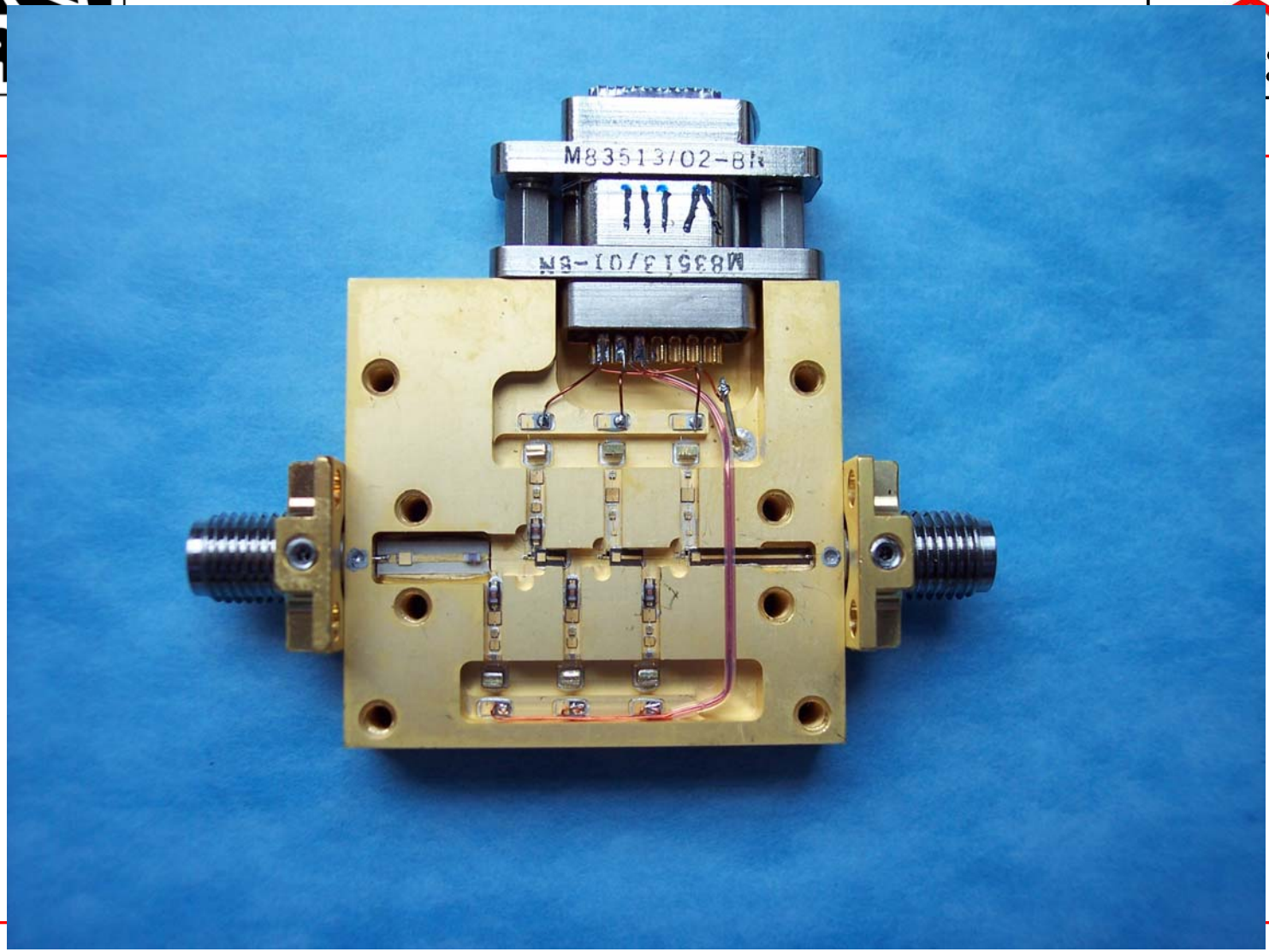

S_04 AT 297 K
DB(|S(1,1)|) (L) SB04V2
DB(|S(2,1)|) (R) SB04V2
DB(|S(2,2)|) (L) SB04V2
IRL and ORL (dB)
GAIN (dB)
Frequency (GHz)
0
-5
-10
-15
-20
-25
40
35
30
25
20
15
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


S_BAND BALANCED AMPLIFIER AT 15 K
NOISE TEMPERATURE (K)
GAIN (dB)
FREQUENCY (GHz)
NOISE
GAIN
0
2
4
6
8
10
12
14
16
18
20
20
24
28
32
36
40
1.5
2
2.5
3
3.5
4
4.5

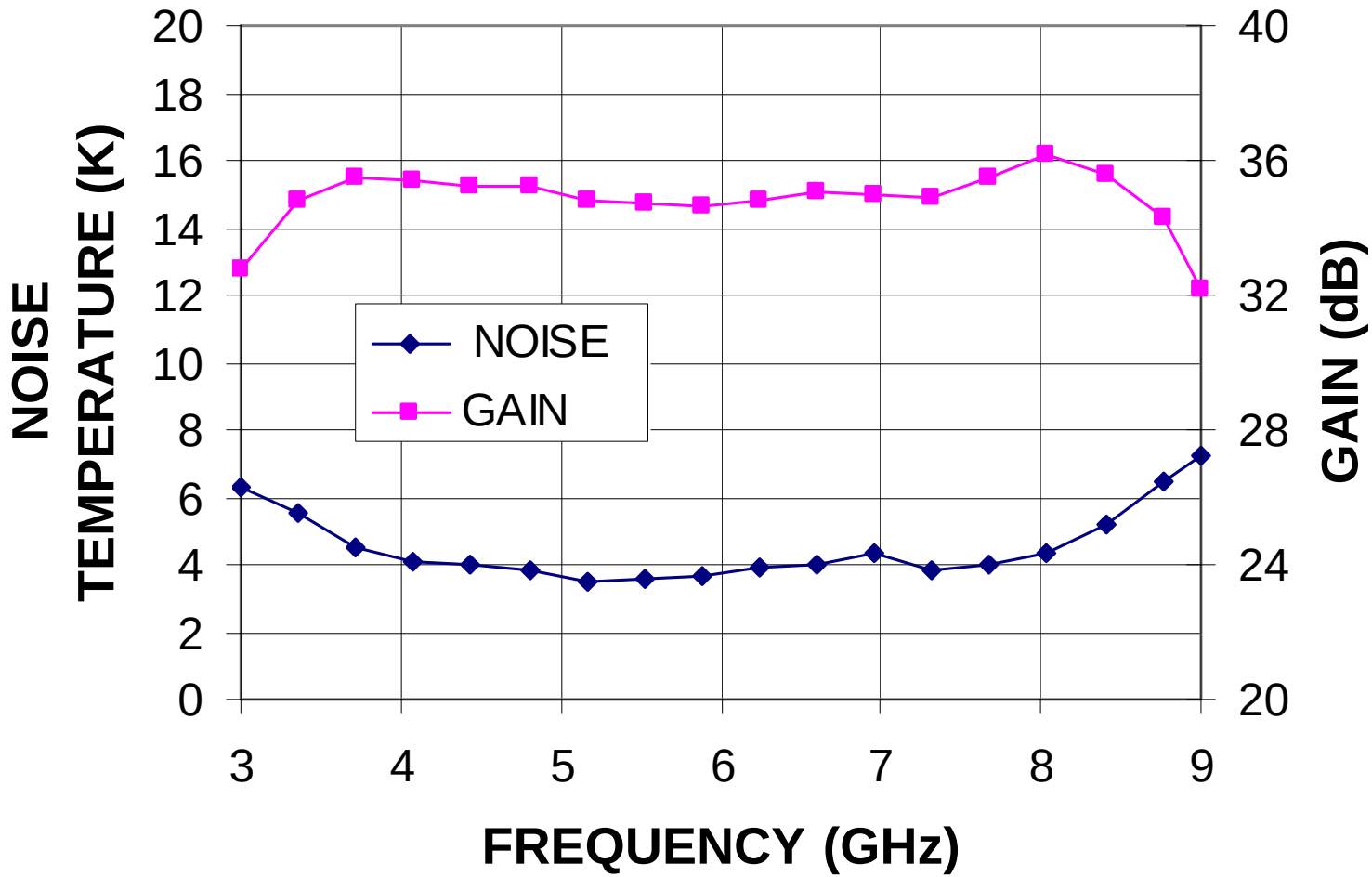
2- 4 GHz Amplifier at



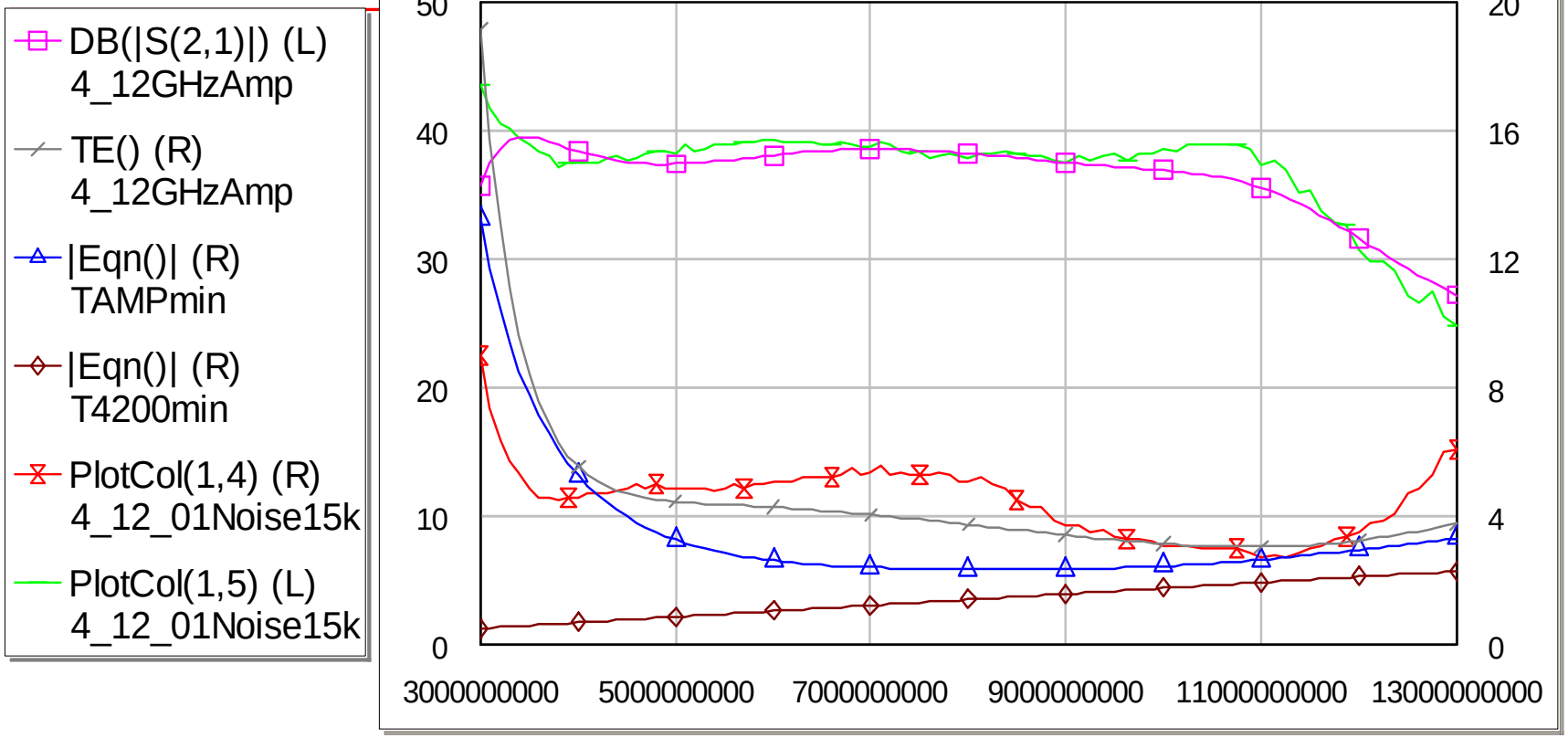

4_8 GHz Amplifier at Room Temperature
DB(|S(1,1)|) (L) C03V3
DB(|S(2,1)|) (R) C03V3
DB(|S(2,2)|) (L) C03V3
IRL and ORL (dB)
Gain (dB)
Frequency (GHz)
20
10
0
-10
-20
45
40
35
30
25
3
4
5
6
7
8
9


M83513/02-8N
111A

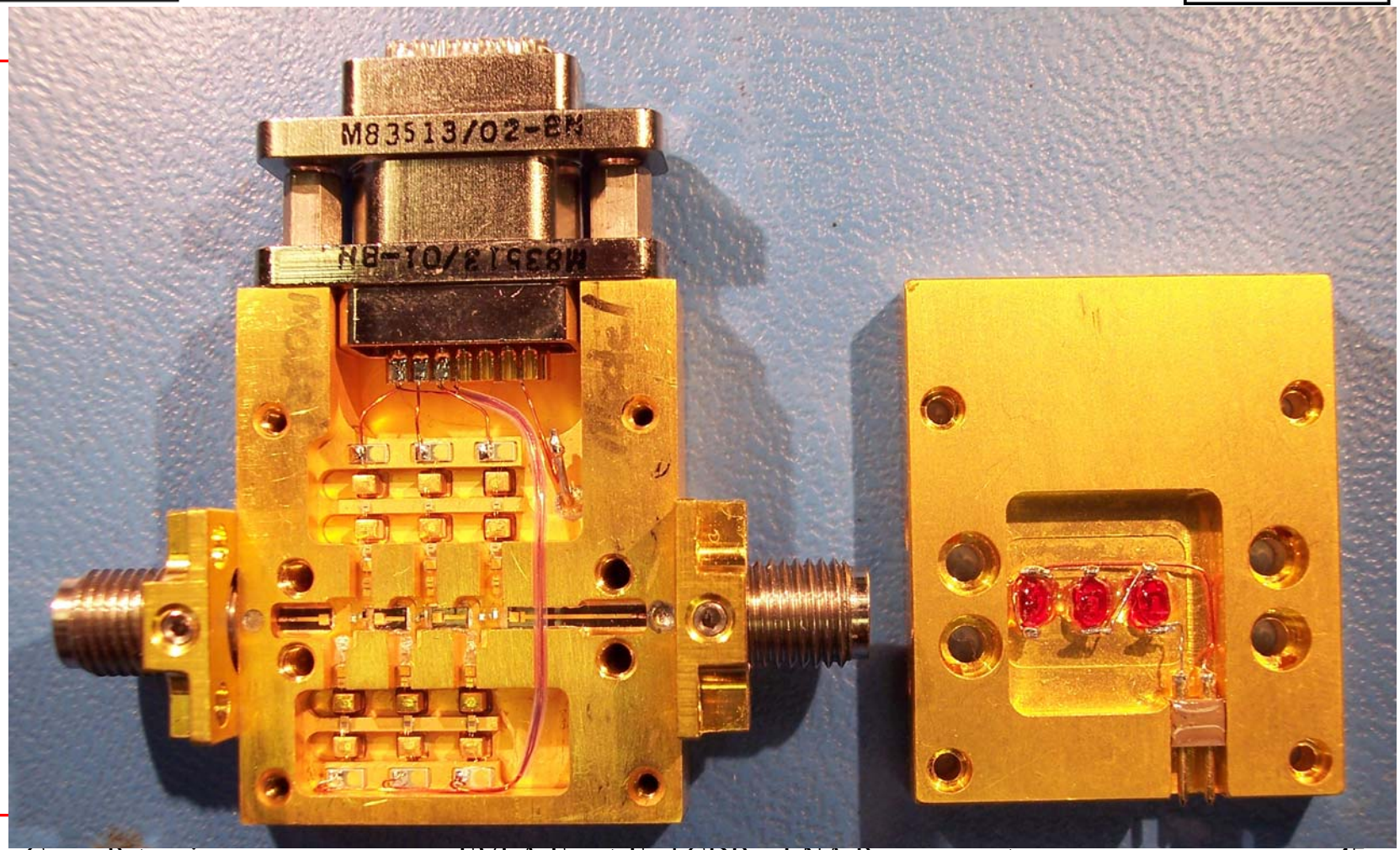
4_8 GHz AMPLIFIER AT 15 K



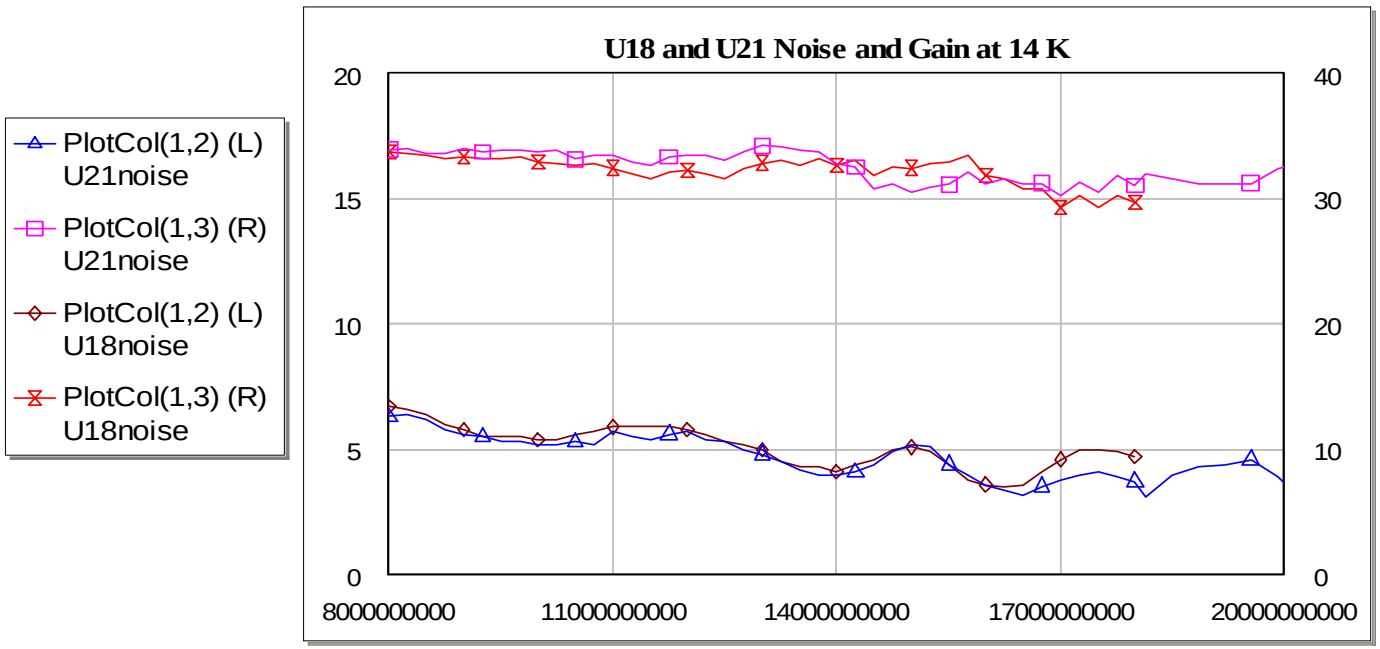
GHz 4-12 Amplifier at 15 K

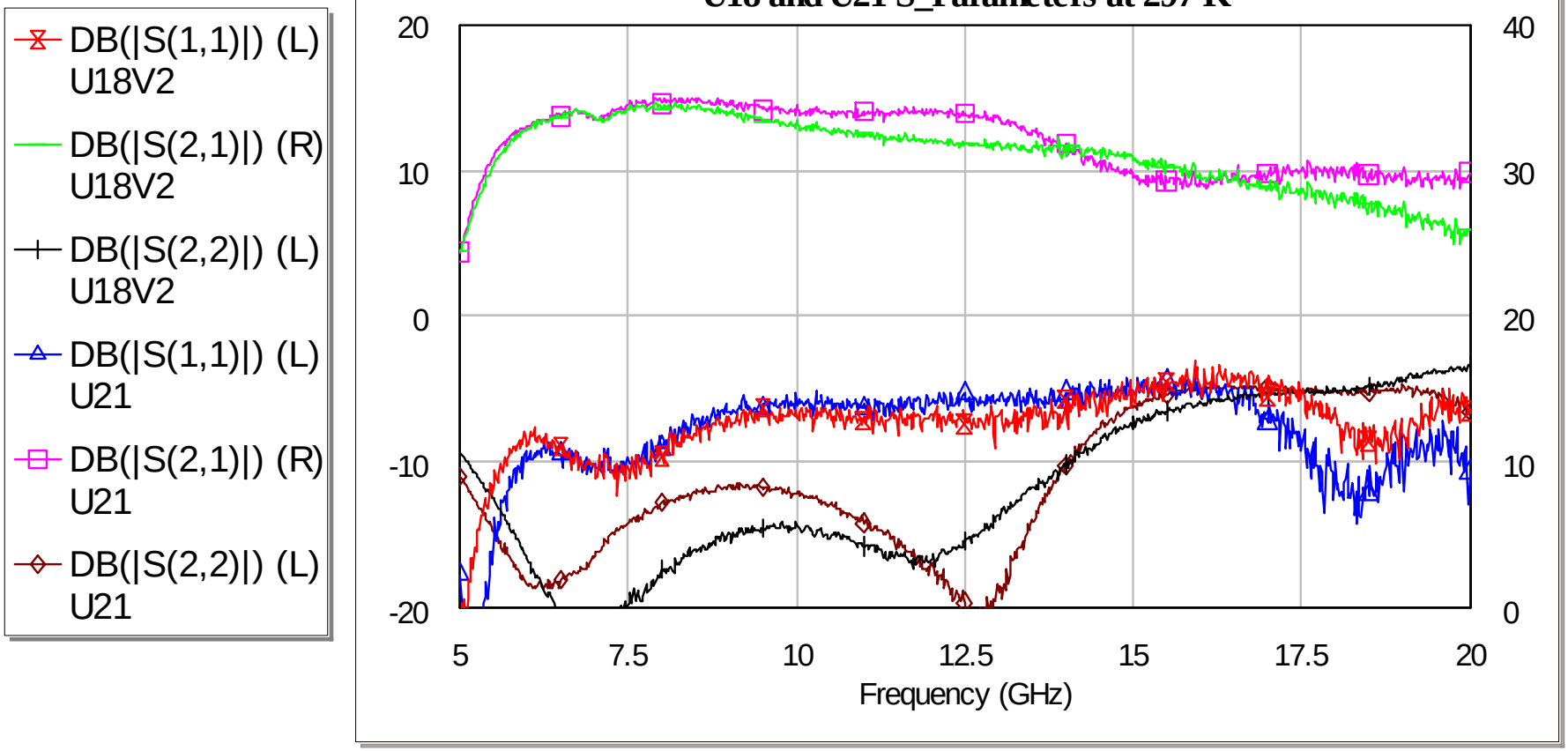


8-18 GHz Amplifier

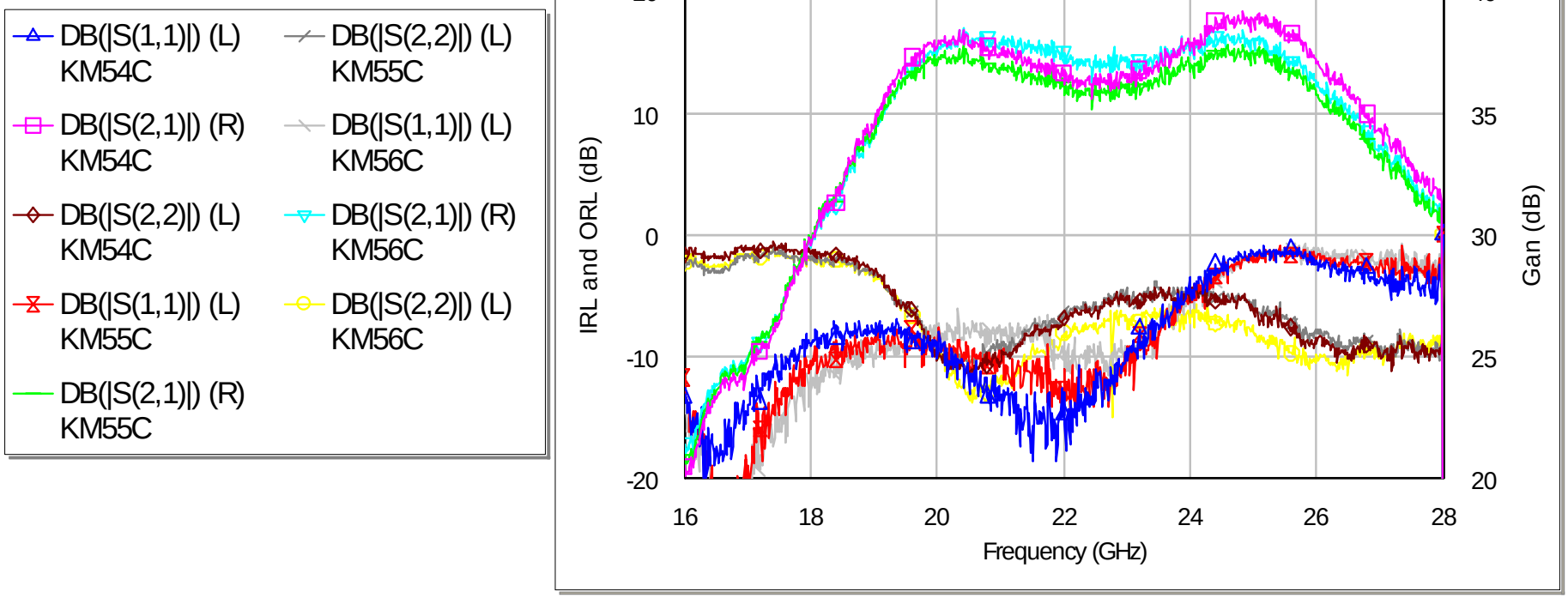


8-18 GHz Amplifier at 15 K

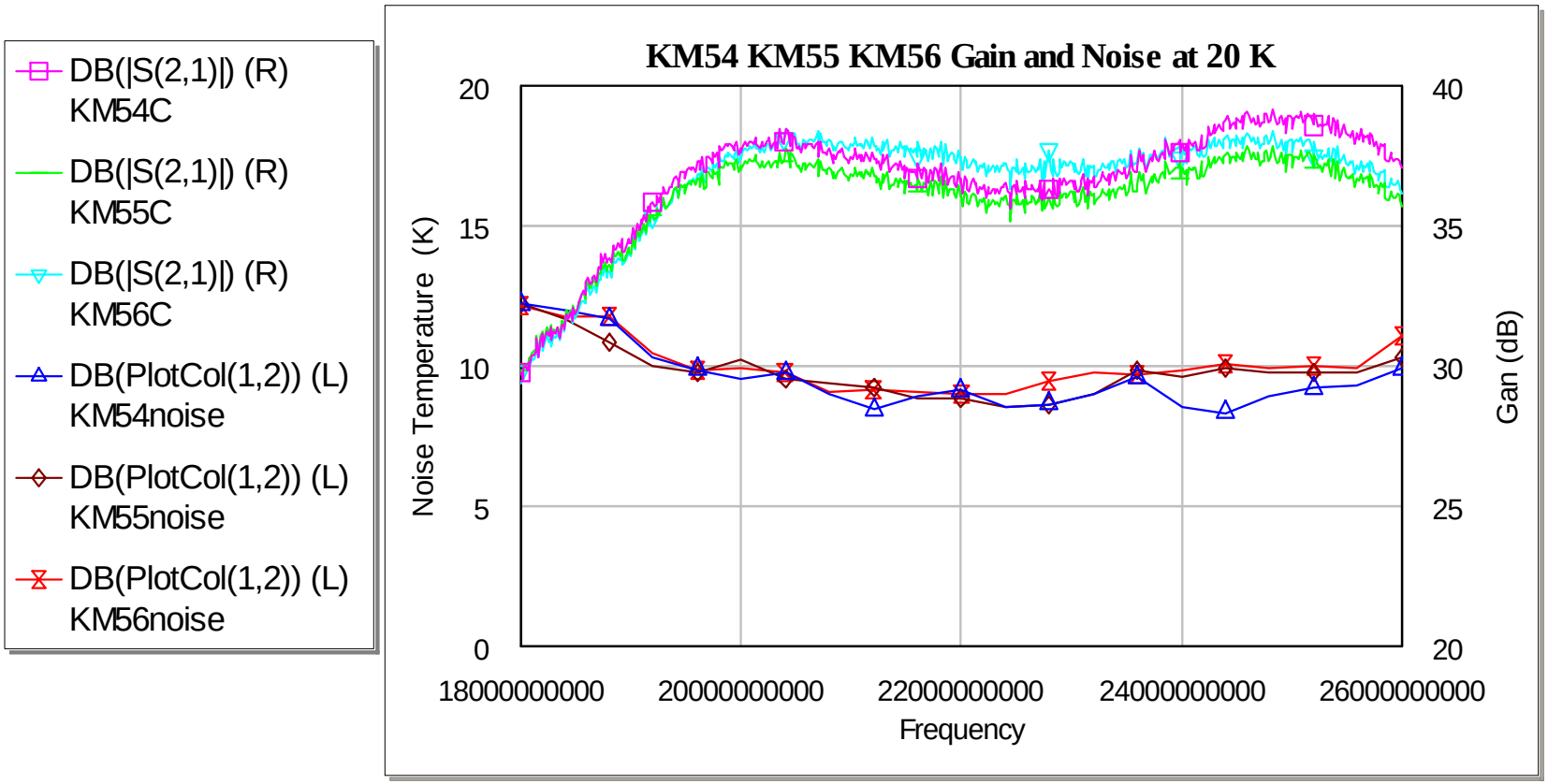


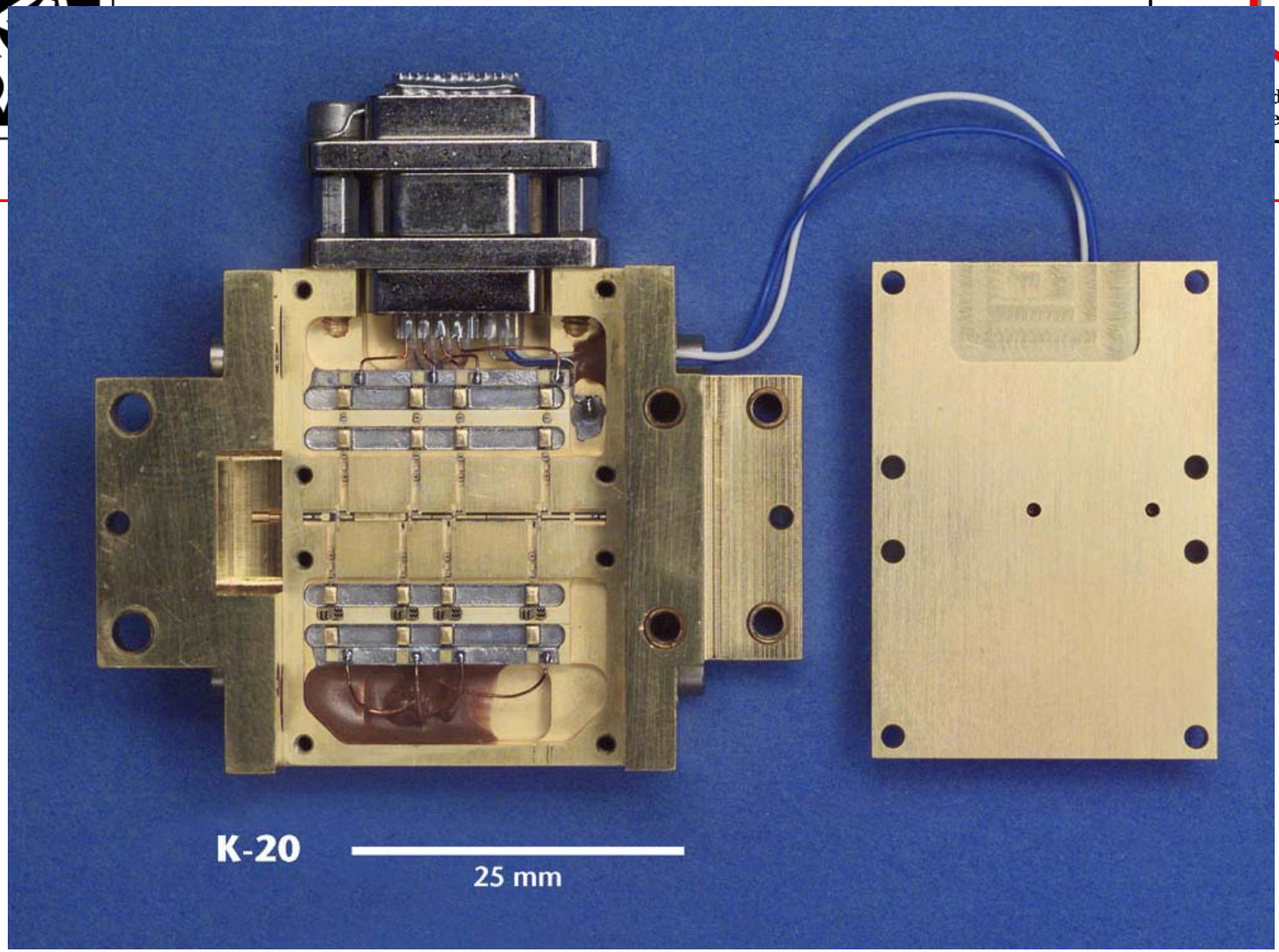

U18 and U21 S_Parameters at 297 K
DB(|S(1,1)|) (L) U18V2
DB(|S(2,1)|) (R) U18V2
DB(|S(2,2)|) (L) U18V2
DB(|S(1,1)|) (L) U21
DB(|S(2,1)|) (R) U21
DB(|S(2,2)|) (L) U21
20
10
0
-10
-20
40
30
20
10
0
5
7.5
10
12.5
15
17.5
20
Frequency (GHz)

K-Band Amplifier at 15 K

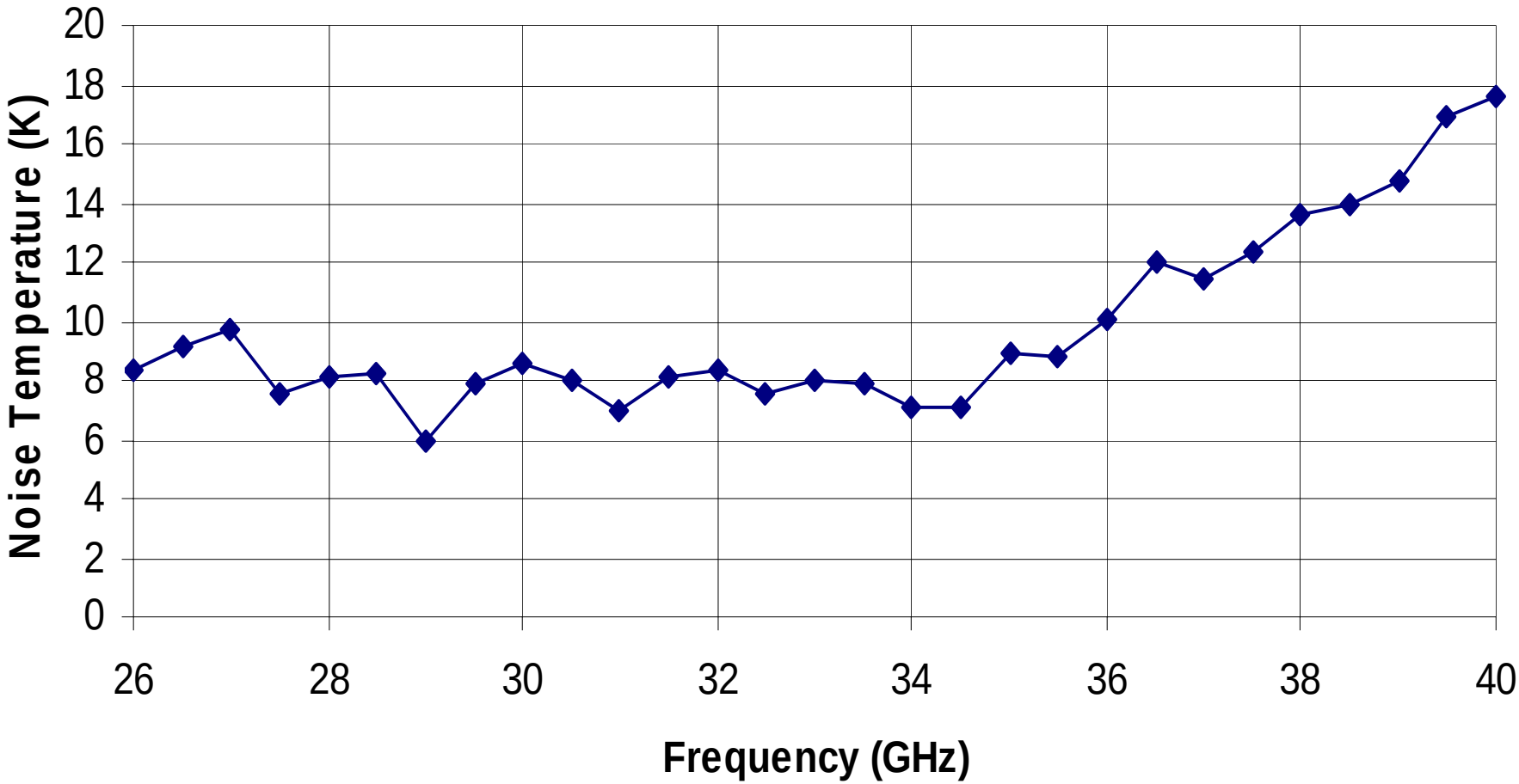


K-Band Amplifier at 15 K

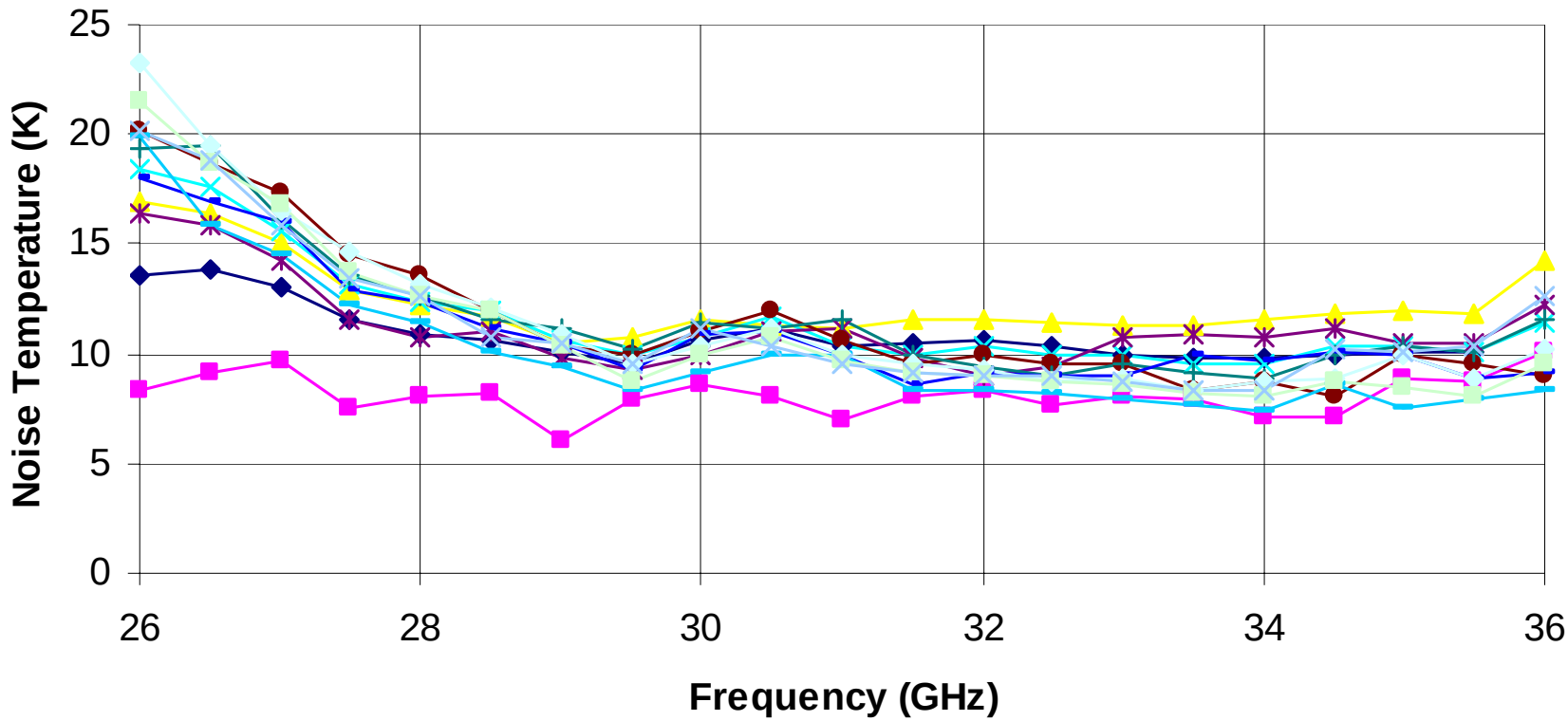


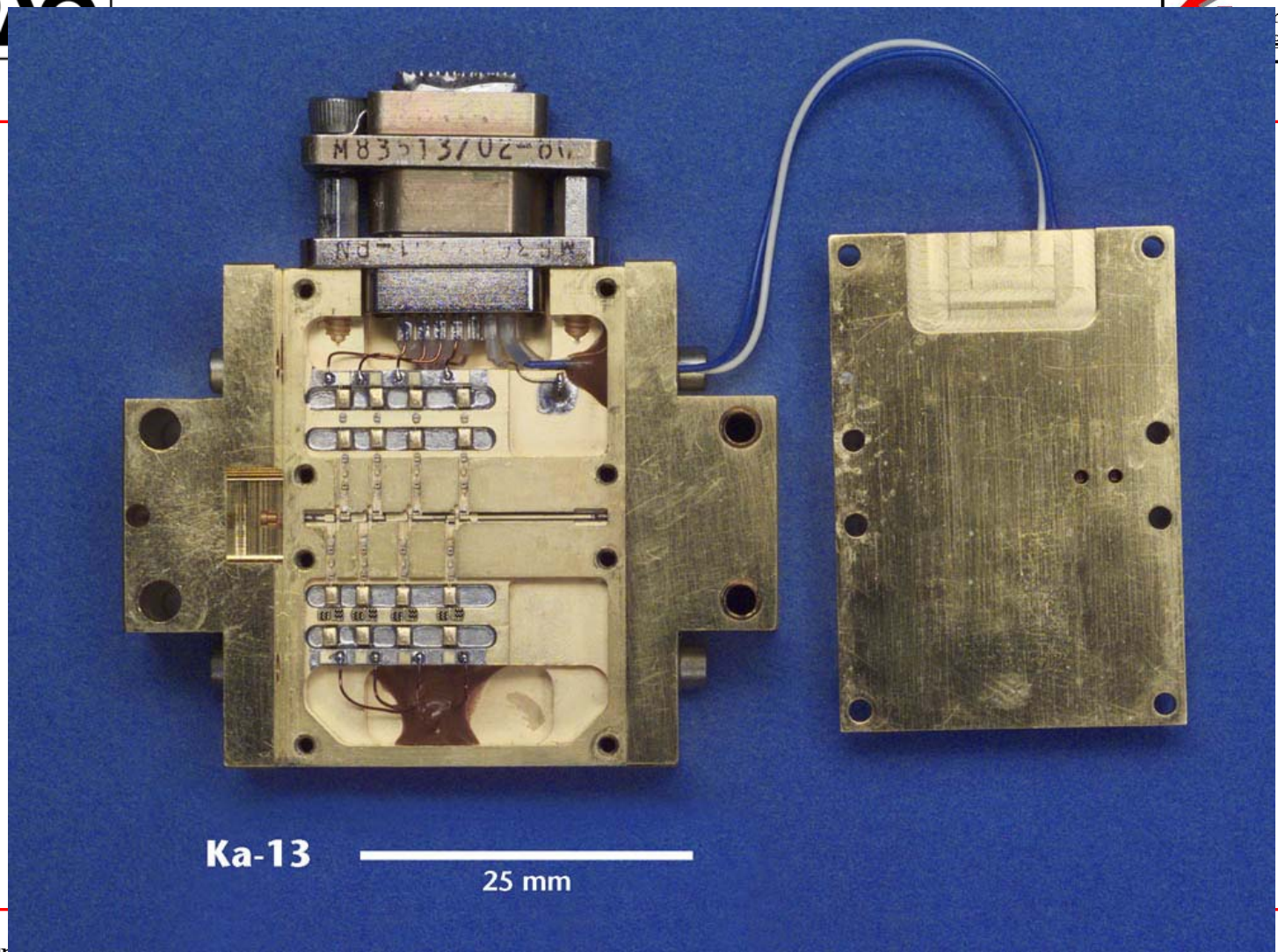

K-20
25 mm

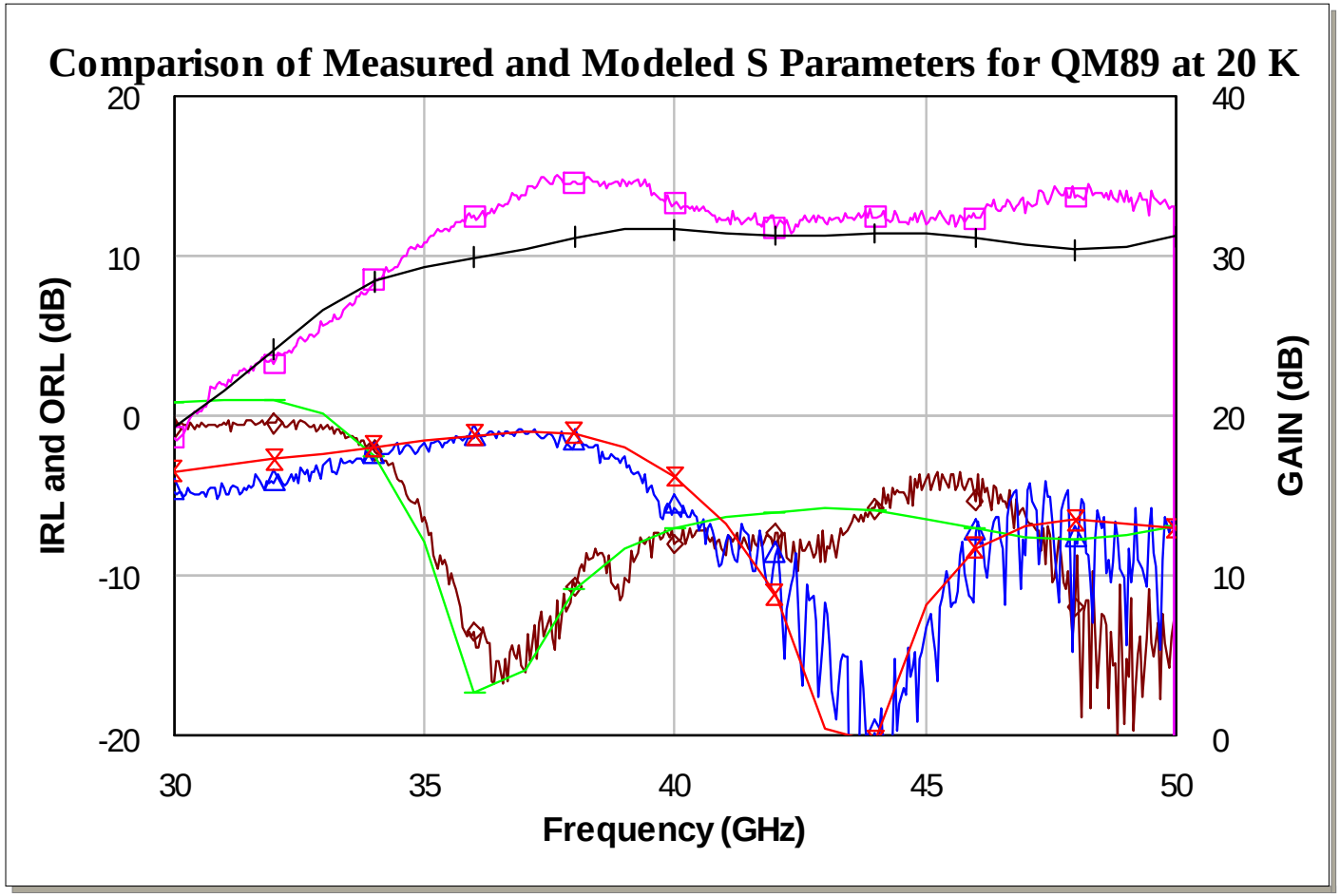
Ka-BAND CRYOGENIC RECEIVER NOISE TEMPERATURE (AM13)

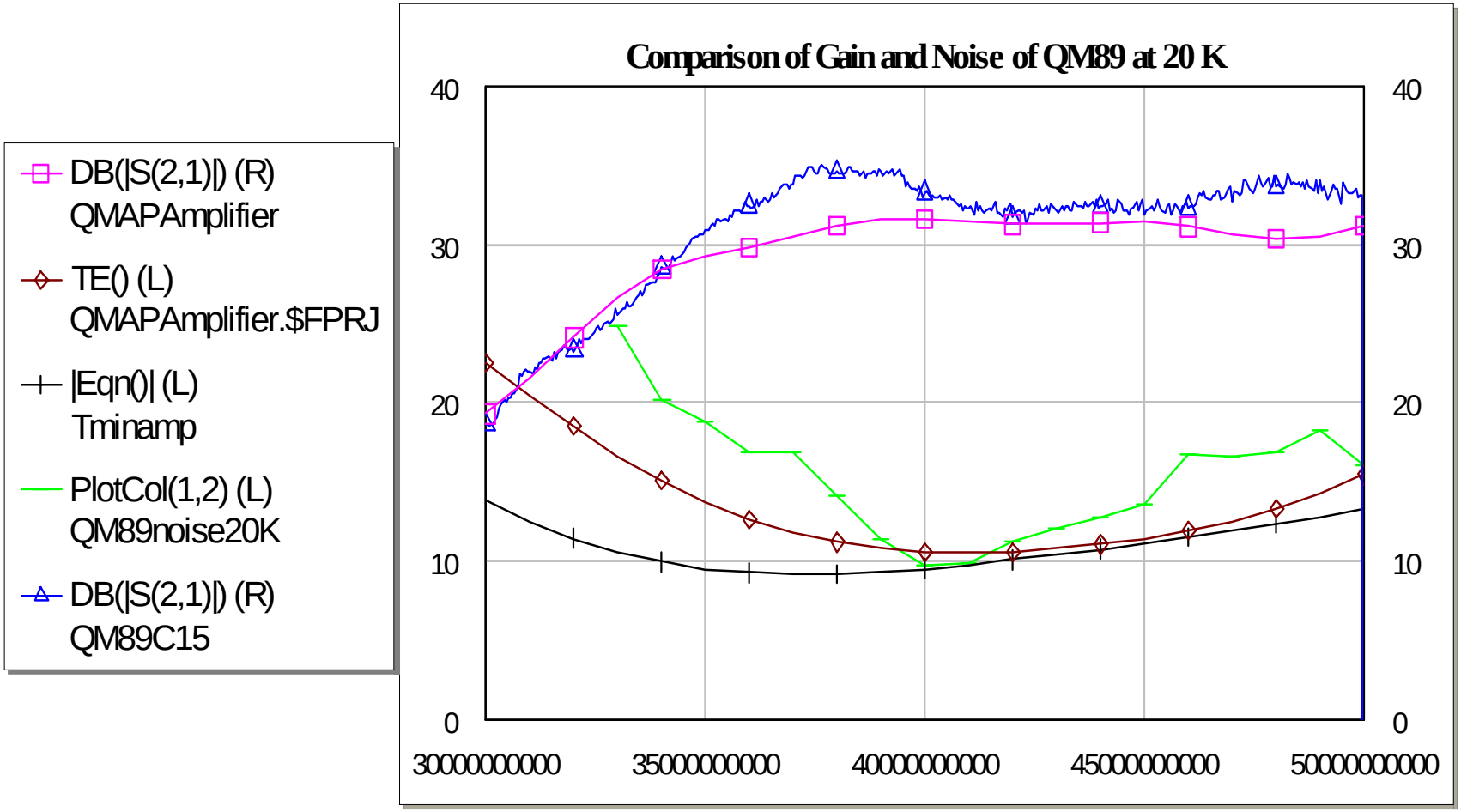


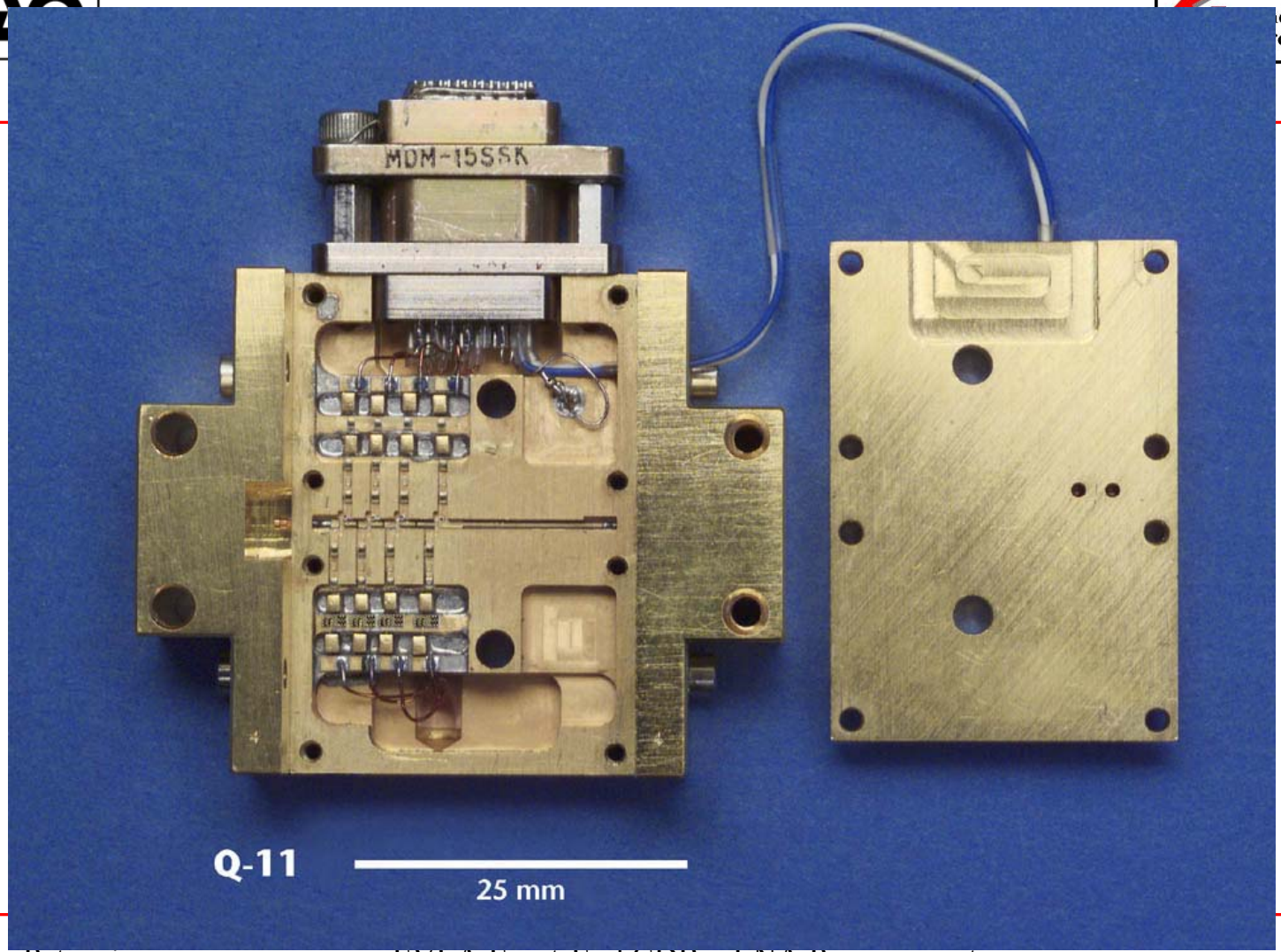
EVLA Ka-BAND AMPLIFIERS WITH 4080 CRYO3 DEVICE AT 19 K




Ka-13
25 mm


Comparison of Measured and Modeled S Parameters for QM89 at 20 K
DB(|S(1,1)|) (L) QMAPAmplifier
DB(|S(2,2)|) (L) QMAPAmplifier
DB(|S(2,1)|) (R) QMAPAmplifier
DB(|S(1,1)|) (L) QM89C15
DB(|S(2,1)|) (R) QM89C15
DB(|S(2,2)|) (L) QM89C15
IRL and ORL (dB)
GAIN (dB)
Frequency (GHz)
20
10
0
-10
-20
40
30
20
10
0
30
35
40
45
50


Comparison of Gain and Noise of QM89 at 20 K
DB(|S(2,1)|) (R)
QMAPAmplifier
TE() (L)
QMAPAmplifier.$FPRJ
|Eqn()| (L)
Tminamp
PlotCol(1,2) (L)
QM89noise20K
DB(|S(2,1)|) (R)
QM89C15
40
30
20
10
0
30000000000
35000000000
40000000000
45000000000
50000000000


MDM-15SSK
Q-11
25 mm