EVLA Receivers

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EVLA Front-End & Feed Systems

Presentation Outline

- Scope of the Front-End Project
- Feeds
- Broadband OMT Development Progress
- Receiver Production Schedule
- Staffing Issues

→ More information on EVLA receiver specifications in Backup Slides at the end…

Top-Level EVLA Receiver Plan

- Provide "Core" Receiver Bands for every newly outfitted antenna:
  - **L, C, X(Transition), K & Q-Band**
- Ka-Band (as it becomes available)
- Add brand new EVLA Receivers at a later date:
  - **S, Ku, X-Band**

X-Band (8-12 GHz) *Transition & EVLA Rx's*

- VLA has a decent (albeit narrow) X-Band system
- EVLA will reuse existing 8.0-8.8 GHz early on
- "Transition" receiver can be mounted on old or new X-Band feeds
- Typically used for "First Fringes"
- New 8-12 GHz system will be prototyped in 2009 with production scheduled for 2010
- But there are design issues – more details later…

K-Band (18-26.5 GHz) *Interim & EVLA Rx's*

- EVLA K-Band receivers are upgraded 18-26.5 GHz systems already on the VLA.
- Improvements include:
  - **New Cryo-3 LNA's for improved sensitivity**
  - **New 18-26.5 GHz to 8-16.5 GHz Block Converter scheme**
  - **Modifications to feed (new ring-load section) and dewar (thicker top plate) to improve electrical & mechanical interface**
- "Interim" K-Bands have old VLA-style Card Cages & will be retrofitted with new EVLA units later
  - **Interim K-Band receivers have full EVLA tuning & sensitivity but fewer Monitor & Control features**
  - **3 of 12 receivers completed to date are fully EVLA-compliant**
- Almost all production components have been purchased.

Q-Band (40-50 GHz)
Interim & EVLA Rx's

- EVLA Q-Band receivers are upgraded 40-50 GHz systems already on the VLA.
- Improvements include:
  - **New Cryo-3 LNA's for improved sensitivity**
  - **New custom 40-50 GHz MMIC post-amps (designed at Caltech, built at NRAO) to improve sensitivity**
  - **New 40-50 GHz to 8-18 GHz Block Converter scheme**
- "Interim" Q-Bands have old VLA-style Card Cages & will be retrofitted with new EVLA units later
  - **Interim Q-Band receivers have full EVLA tuning & sensitivity but fewer Monitor & Control features**
  - **1st fully EVLA-compliant receiver nearly ready for installation**
- Almost all production components have been purchased

L-Band (1-2 GHz)
Interim & EVLA Rx's

- Progress on the EVLA L-Band front-end has been slow
  - **Required an octave bandwidth Ortho-Mode Transition (OMT) to be developed**
  - **1-2 GHz OMT design scaled for use at both the C and S-Band**
  - **A prototype OMT is currently installed in a Test Rx on Ant 14**
- While waiting for completion of new EVLA design, "Interim" Receivers are being installed on upgraded antennas
  - **Retains original VLA 1.3-1.8 GHz OMT**
  - **Modified with new EVLA 1-2 GHz cooled balanced amplifier gain blocks**
  - **Add 90 degree Hybrid Coupler (replacing old style VLA dielectric slab phase-shifter) to convert linear to circular polarization**
  - **To keep pace with Antenna overhaul, up to 16 Interim L-Band receivers may be required before wideband OMT ready**
  - **OMT Delay is not affecting science with the E/VLA**
- Work is progressing on the production version 1-2 GHz OMT (more later)
- And a new cryogenic dewar and receiver package is being designed

C-Band (4-8 GHz)
Interim & EVLA Rx's

- The new EVLA C-Band (4-8 GHz) receiver uses an octave bandwidth OMT scaled up in frequency from L-Band
  - **OMT design essentially complete & prototypes are undergoing final cryogenic evaluation.**
  - **Design for mass production OMT is well underway**
- While waiting for this wideband OMT, "Interim" Rx's are being installed
  - **Uses modified Atlantic Microwave 4.5-5.2 GHz Sloping Septum Polarizer salvaged from the old VLA A-Rack receiver**
  - **Retrofitting of receivers will only require us to swap in the new OMT, and add a 90 degree Hybrid & a wideband Noise Diode**
  - **To keep pace with Antenna overhaul, up to 16 Interim C-Band receivers may be required before wideband OMT ready**
- New C-Band system pioneers the EVLA "Common Dewar" design which will be copied, as much as possible, in other new EVLA Rx's (Ka, Ku &X)
- Most production components have been purchased (except OMTs & NDs)

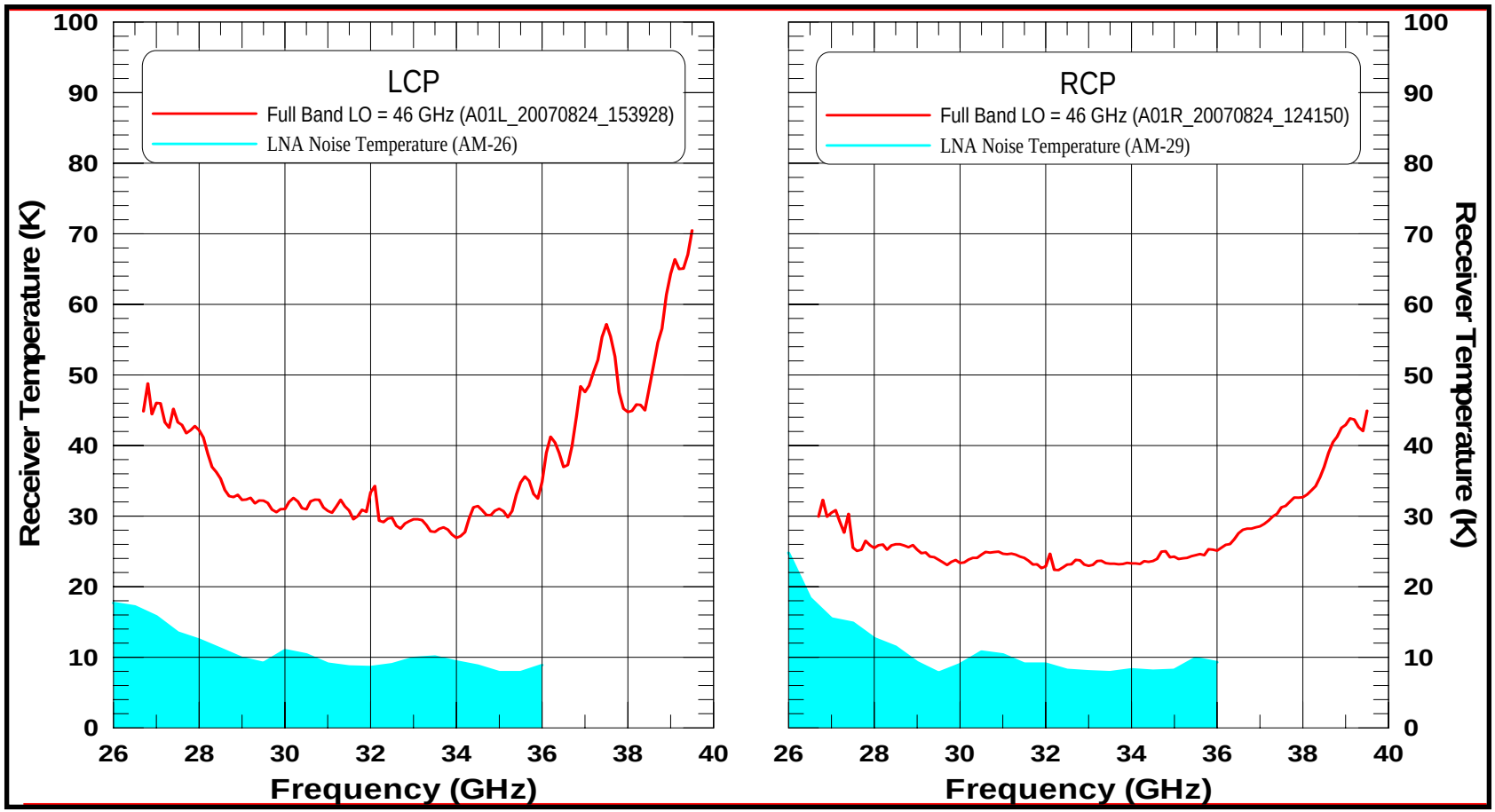
Ka-Band (26-40 GHz) *EVLA Receiver*

- The Ka-Band (26-40 GHz) receiver provides a brand new discovery space for the VLA
- Due to other pressures and diversions, Ka-Band receiver development has been slower than planned
- Relatively straightforward "hybrid" of existing K & Q-Band receiver designs
  - **Scaled K-Band Polarizer largely verified in the GBT 1cm receiver.**
  - **Waveguide output similar to Q-Band**
- Uses novel MMIC-based downconverter (designed at Caltech, built at NRAO) which provides an RF post-amp, mixer and IF post-amp as well as an active LO tripler
- Prototype receiver currently undergoing evaluation
- Production receivers to begin in late 2007/early 2008

Hot off the Press Results

Ka-Band Prototype Receiver

Block Converter Mode with LO = 46 GHz



S, Ku & X-Band
EVLA Receivers

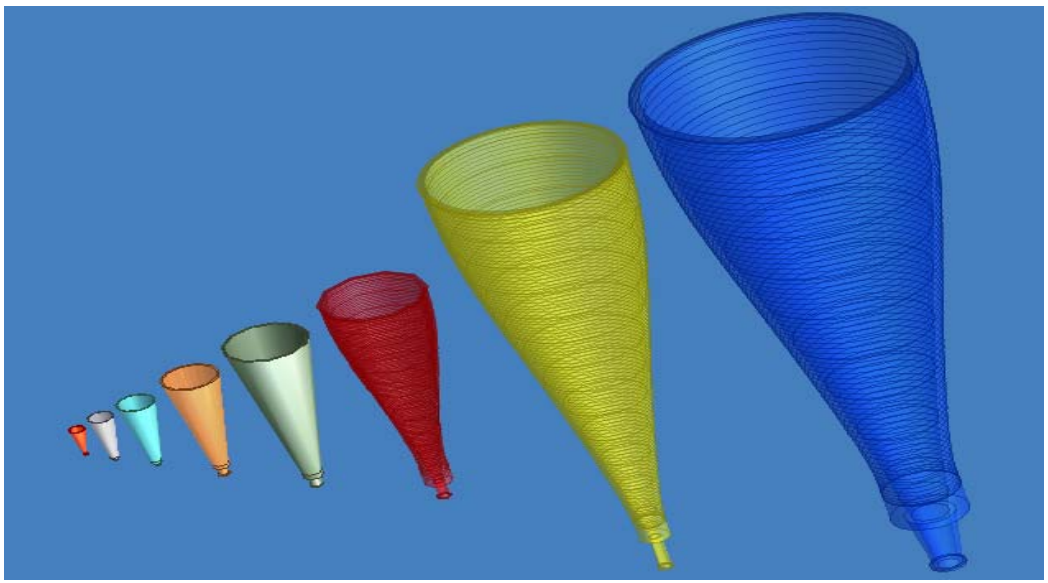
- S-Band (2-4 GHz) is a brand new receiver
  - **Scaling of L & C-Band OMT to S-Band began in May 2007**
  - **Prototype OMT evaluation expected late in 2007**
  - **New S-Band receiver will re-use old L-Band dewar**
  - **Production of EVLA receiver will begin in 2008**

- New Ku-Band (12-18 GHz) will replace the current "crummy" 14.4-15.4 GHz A-Rack system on the VLA
  - **Based on scaled Srikanth-Wollack K-Band circular polarizer**
  - **Prototype development scheduled for 2008 with production beginning in 2010**
  - **Ku-Band capability will be sacrificed as each antenna is outfitted**

- New EVLA X-Band design will cover 8-12 GHz
  - **Polarizer design under study (more later)**
  - **Prototype evaluation expected to begin in 2009**
  - **Production begins in 2010**

EVLA Feed System

All feeds are compact or linear taper corrugated horns with ring loaded mode converters



Q A K U X C S L

Outdoor Antenna Test Range

Pattern Measurements & VSWR Tests on Prototype S-Band Feed

OATR Used for L, S & C-Band Feeds

Acknowledgments

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Jesse Pomeroy
John Wall
Troy Jensen

EVLA Feeds
Status & Progress

Rx Band	Need	No. as of Sept 2007	Complete Date	Cost	Comment
L	29	22	2008-Q3	$1,121K	Laminated ; In production
S	29	1	2009-Q4	$912K	Laminated ; Prototype tested
C	29	29	Done	$260K	Machined ; In storage
X	29	2	2012	$213K	Machined ; 2 prototypes (Ant 24)
Ku	31	0	2012	$102K	Machined ; 2 prototypes (2007-Q4)
K	31	31	Done	$31K	Machined ; Modified VLA
Ka	31	31	Done	$24K	Machined ; In storage
Q	31	31	Done	$2K	Machined ; Existing VLA

OMT Requirements

All EVLA receivers will need Low-Loss Circular Polarizers

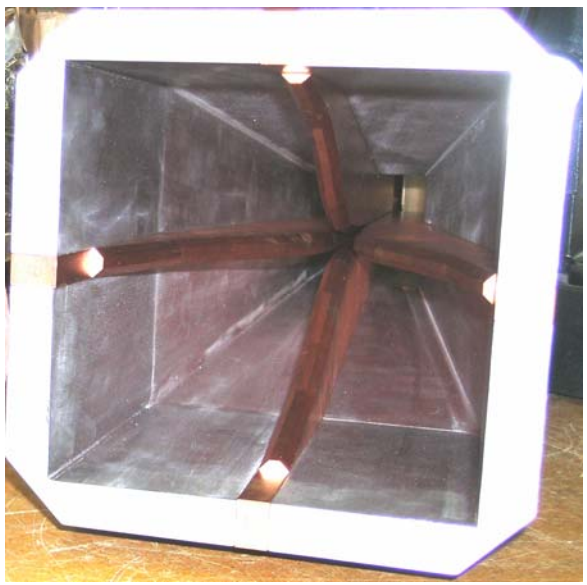
Band	Freq (GHz)	Bandwidth Ratio	Circular Polarizer Type
L	1-2	2.00:1	Quad-Ridge OMT + 90 degree Hybrid Coupler
S	2-4	2.00:1	
C	4-8	2.00:1	
X	8-12	1.50:1	Under Study
Ku	12-18	1.50:1	Srikanth Phase-Shifter + Wollack OMT
K	18-26	1.44:1	
Ka	26-40	1.54:1	
Q	40-50	1.25:1	Commercial Sloping Septum

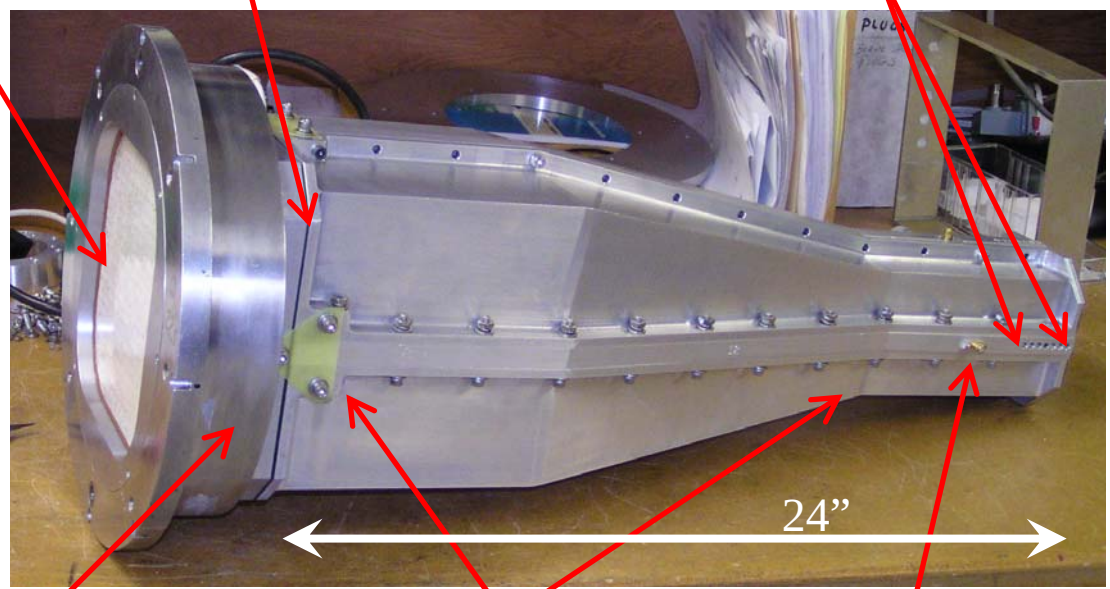
Wideband OMT Development
History

- Paul Lilie began OMT development effort in 2001
  - Novel square cross-section OMT structure for L-Band (1-2 GHz)
  - Trapped Mode suppression feature
  - Extensive HFSS simulations
  - Preliminary evaluation of machined Prototype began middle of 2005
  - Cryogenic testing began Feb 2006
  - Installed on Antenna 14 in Oct 2006
  - Lilie retired in July 2006 (but still comes in to provide assistance)
- Lisa Locke hired in early 2004
  - Worked closely with Lilie
  - Helped scale L-Band OMT to C-Band (4-8 GHz)
  - Preliminary evaluation of machined Prototype began Oct 2006
  - Resigned in Dec 2006 to return to the NWT

L-Band Machined *Prototype OMT*

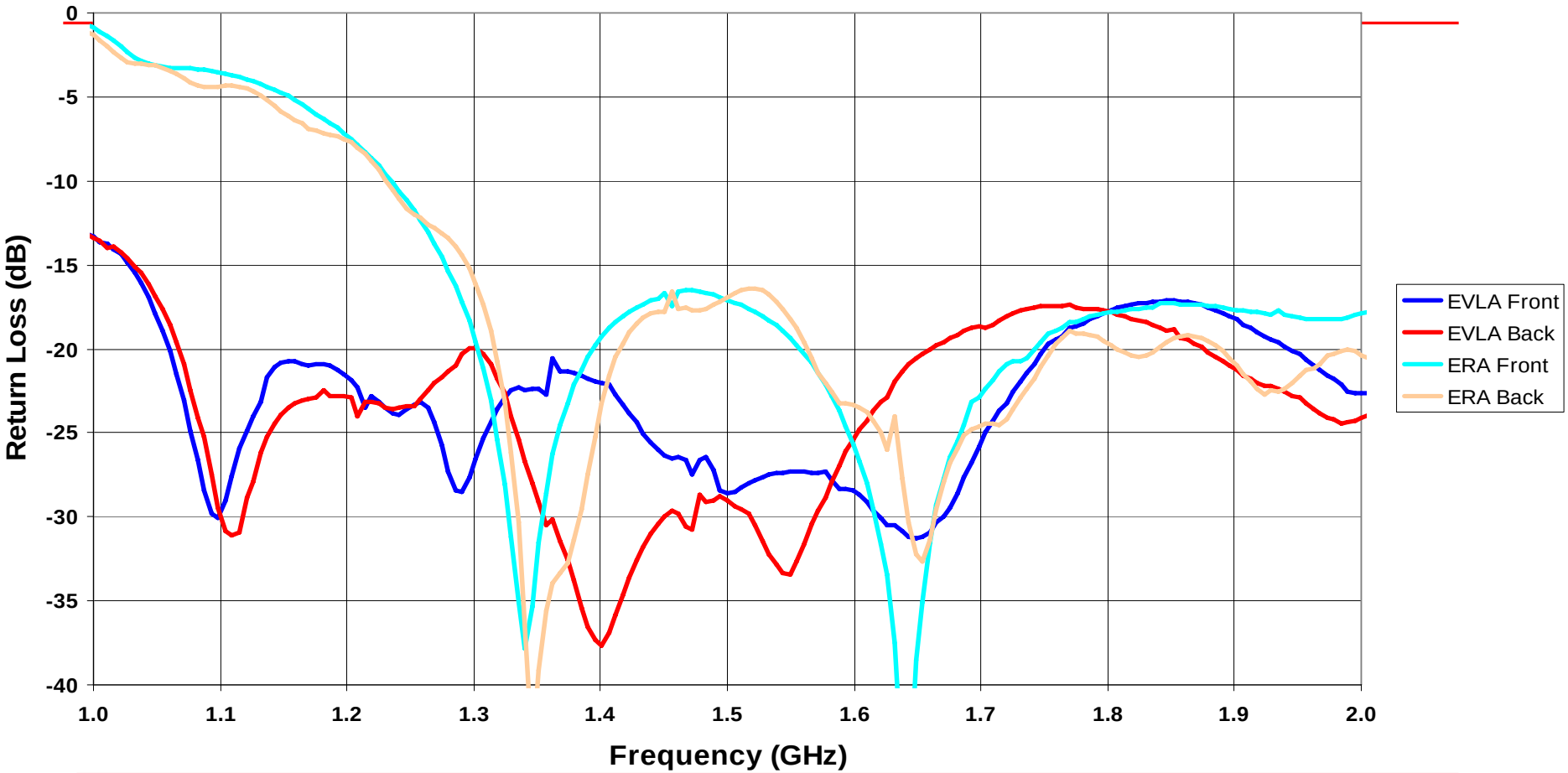
Vacuum Window Thermal Gap Mode Suppression Pins





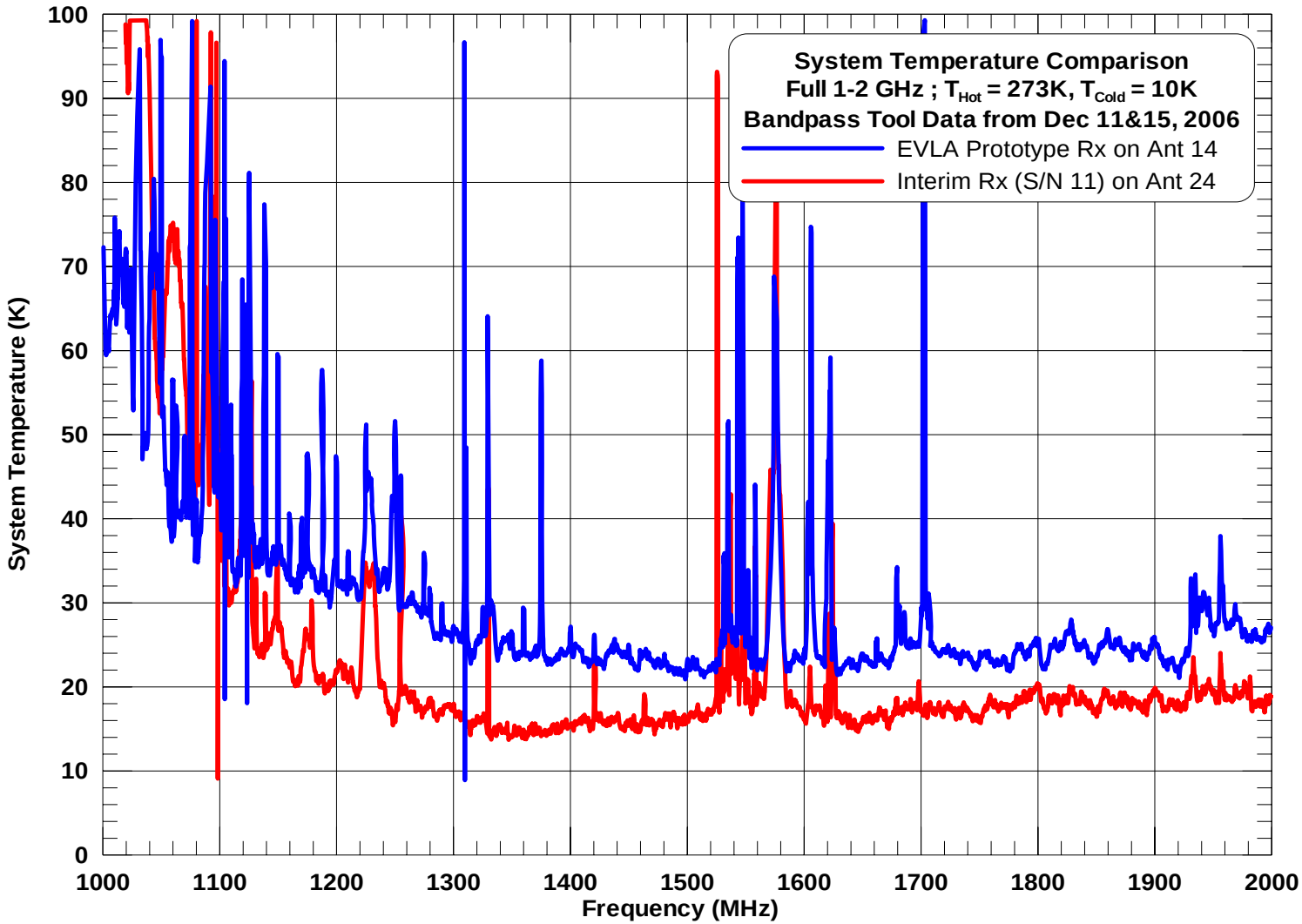
Circular-to-Square Square-to-QR QR-to-Coax

OMT Comparison
EVLA S/N 1 vs. VLA "ERA"
Measured Return Loss



EVLA Prototype on Antenna 14 vs. Interim L#11 on Antenna 24

System Temperature – Full Band

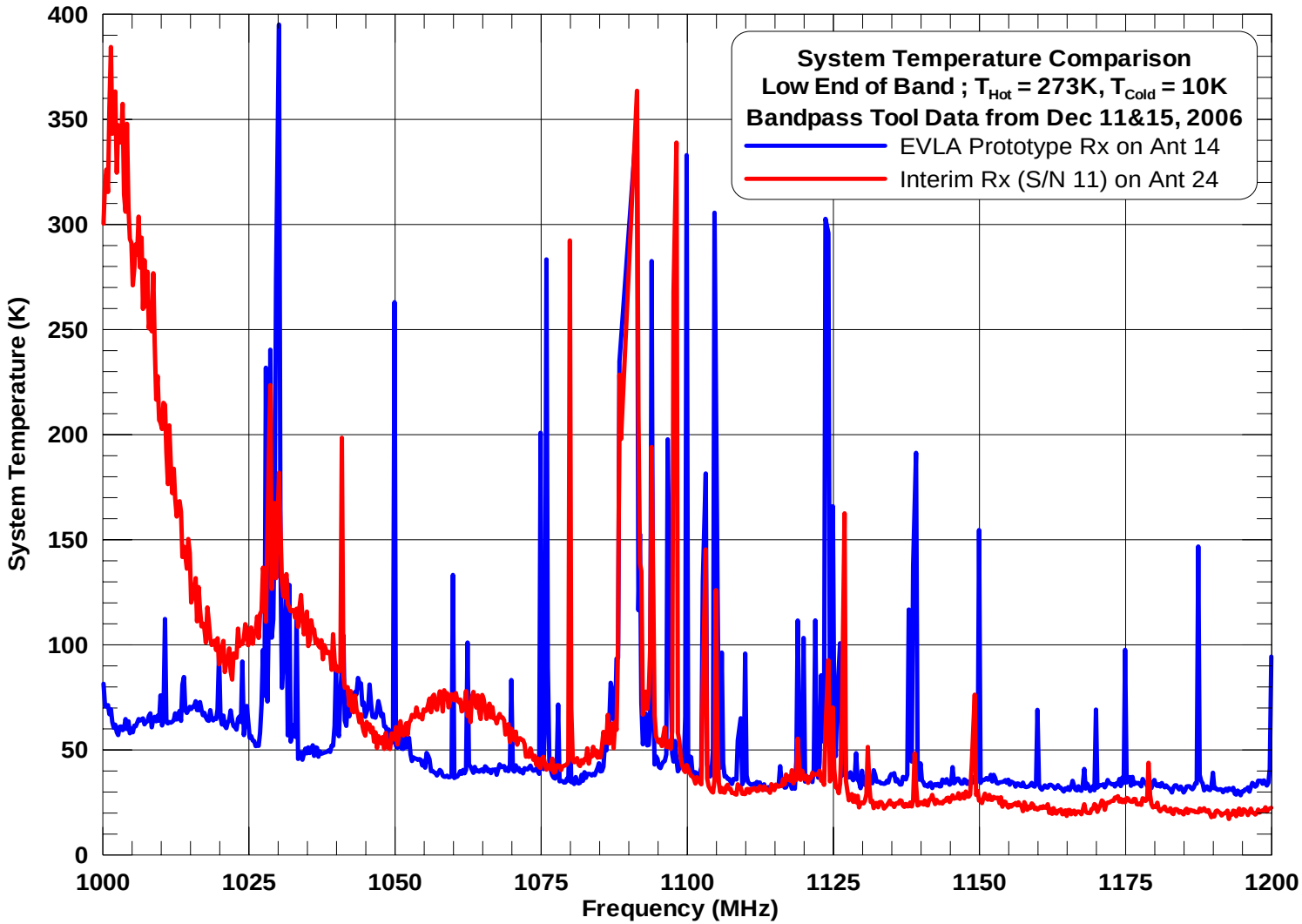


Sensitivity of the prototype OMT is 5-10K worse than we would like.

Future tests will use Cu-plated fins which should reduce the insertion loss of the unit.

EVLA Prototype on Antenna 14 vs. Interim L#11 on Antenna 24

System Temperature – Low End



As expected, the sensitivity of the new OMT is much better at the low end of the band.

Polarization purity will also be far superior

Wideband OMT Development
Current Effort : L-Band

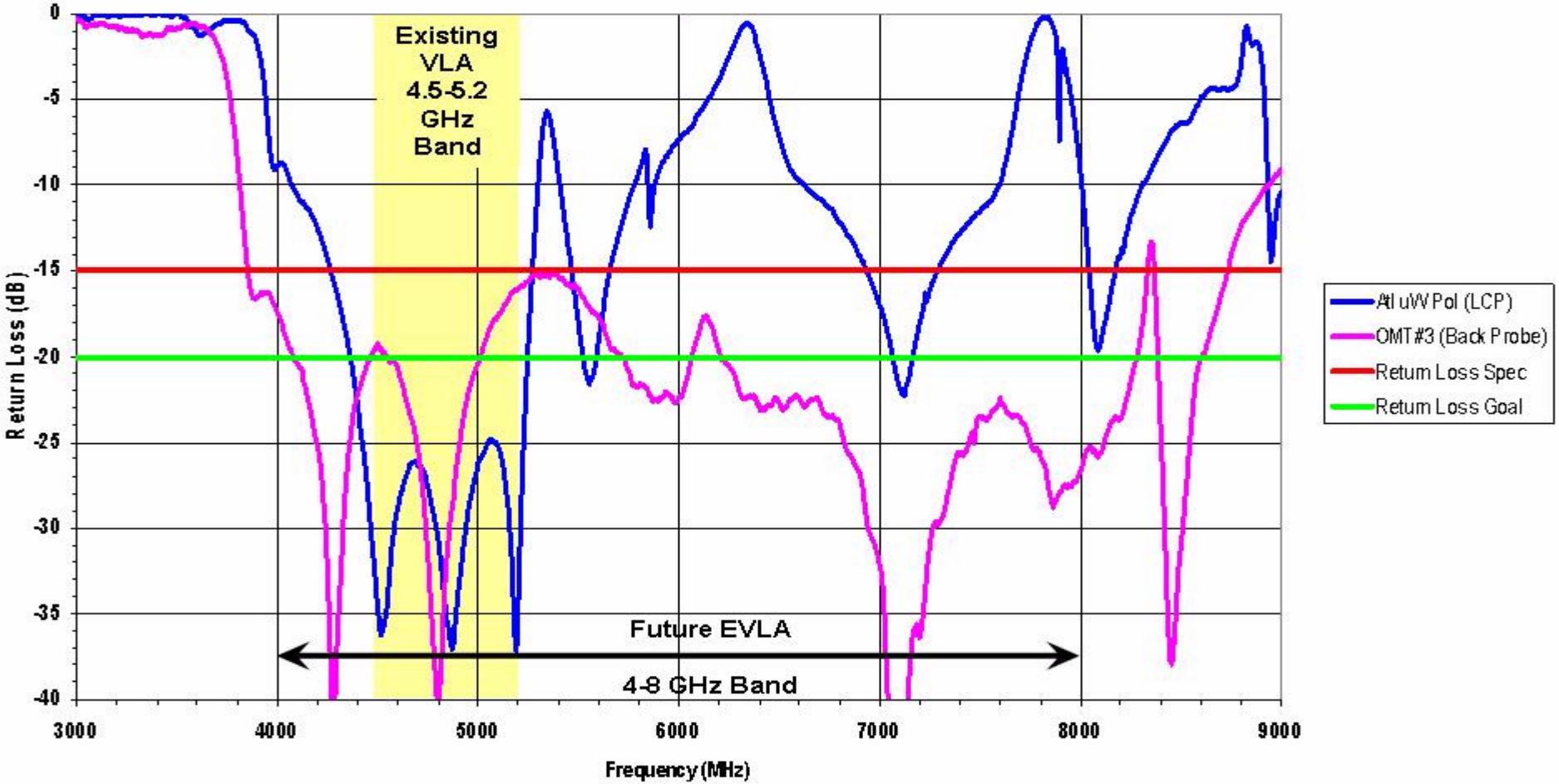
Loss of both RF engineers at this critical stage seriously affected all OMT work and has delayed L & C-Band prototype testing.

- L-Band OMT
  - Hollis Dinwiddie researched methods for mass-production
  - Precision-sand cast molding technique used for two Test Articles
  - Electroformed throat section for shorting pins & coaxial probes
  - Bench tests to begin Fall 2007
  - Cooled tests will require pulling Prototype Rx off of Antenna 14
  - Dinwiddie also designing new dewar for wideband OMT
  - Expect preliminary testing of dewar to begin by end of 2007
  - Expect new EVLA L-Band Receivers to begin in 2008 Q2

Wideband OMT Development
Current Effort : C-Band

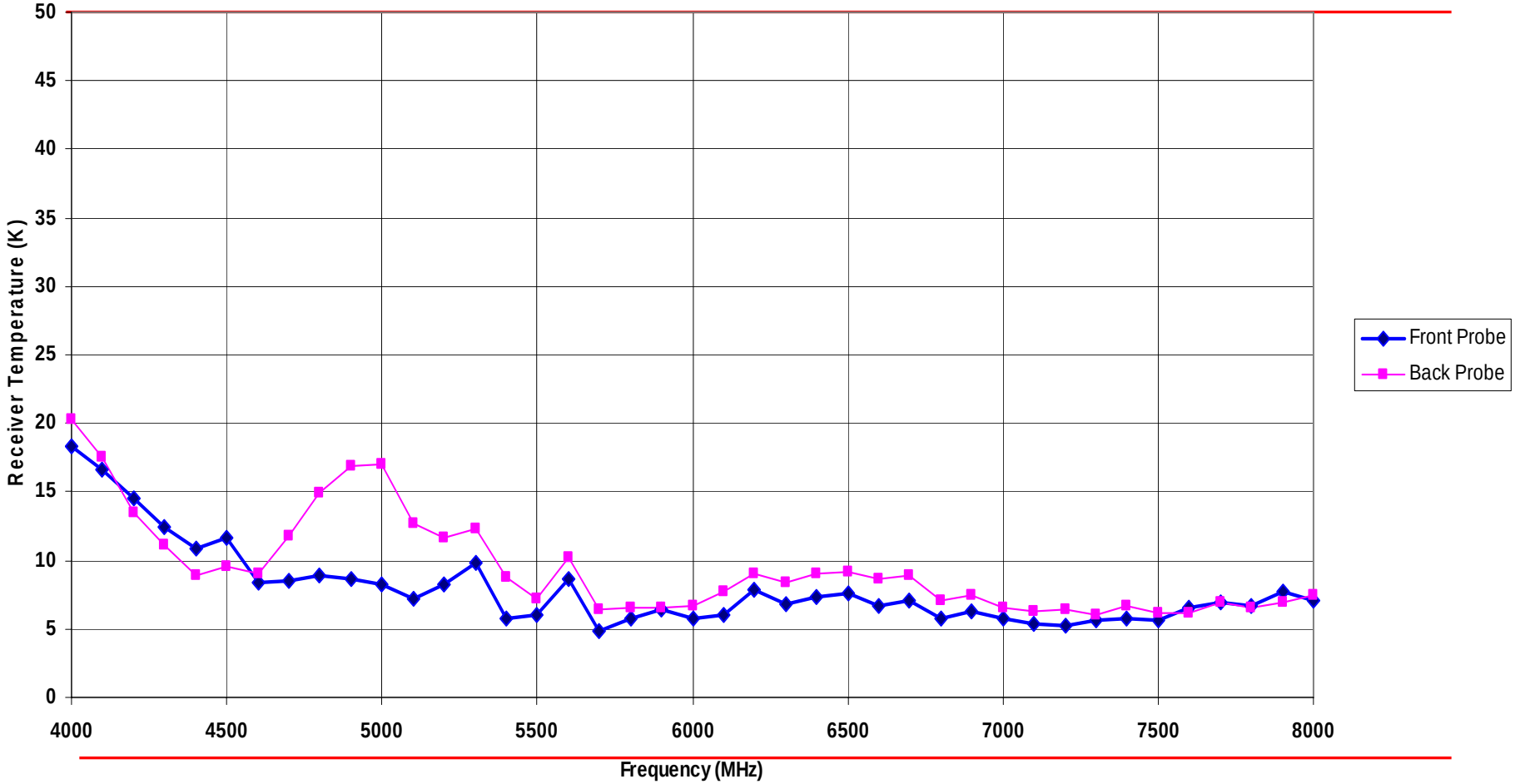
- Prototype C-Band OMT
  - Hayward took over Prototype OMT evaluation
  - Long series of tests to determine ideal fin spacing & probe length
  - Early cryogenic tests showed bumps in T_{Rx} which were <u>eventually</u> traced to problems with the Cal Couplers
  - Next step is to attempt phase-matching of OMT to 90 degree Hybrid, followed by a series of Axial Ratio measurements
  - Wideband OMT to be installed on EVLA later this Fall
- Production C-Band OMT
  - Dinwiddie developing mass production OMT fabrication method (likely a multi-pass electroforming process)
  - Expect new/retrofitted EVLA C-Band receivers to begin in 2008 Q2

Prototype OMT#3 vs. Atlantic Microwave Polarizer *Return Loss Comparison*

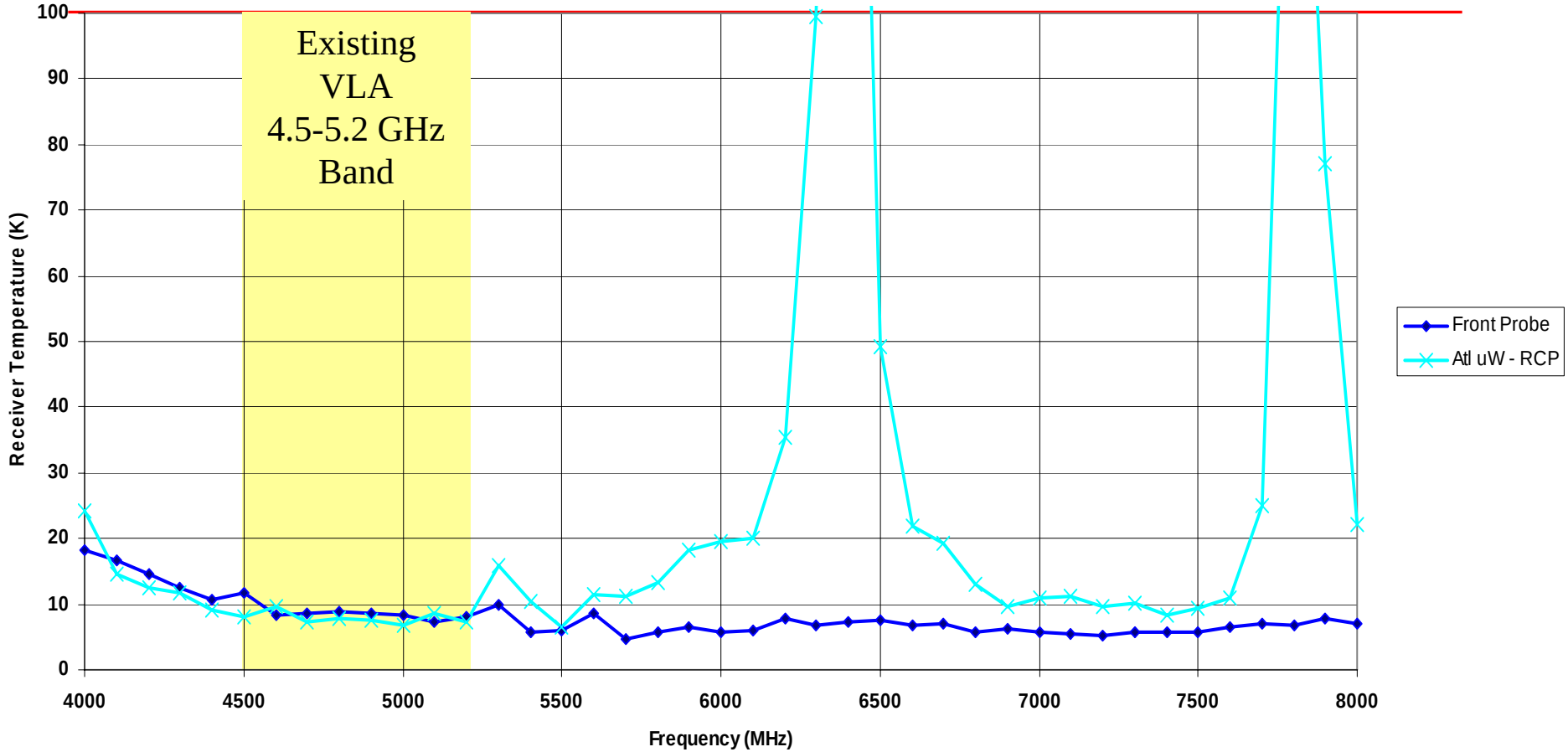


C#06 with Prototype OMT-3

Linear Polarized with no Cal Coupler

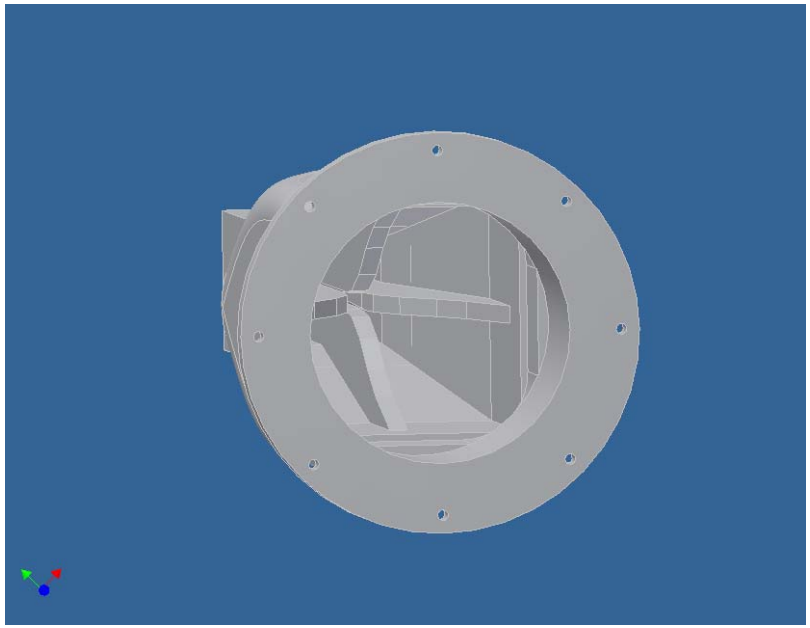


Wideband C#06 with OMT-3 (Linear with no Cal Coupler) versus Interim C#03 with Old VLA-style Circular Polarizer



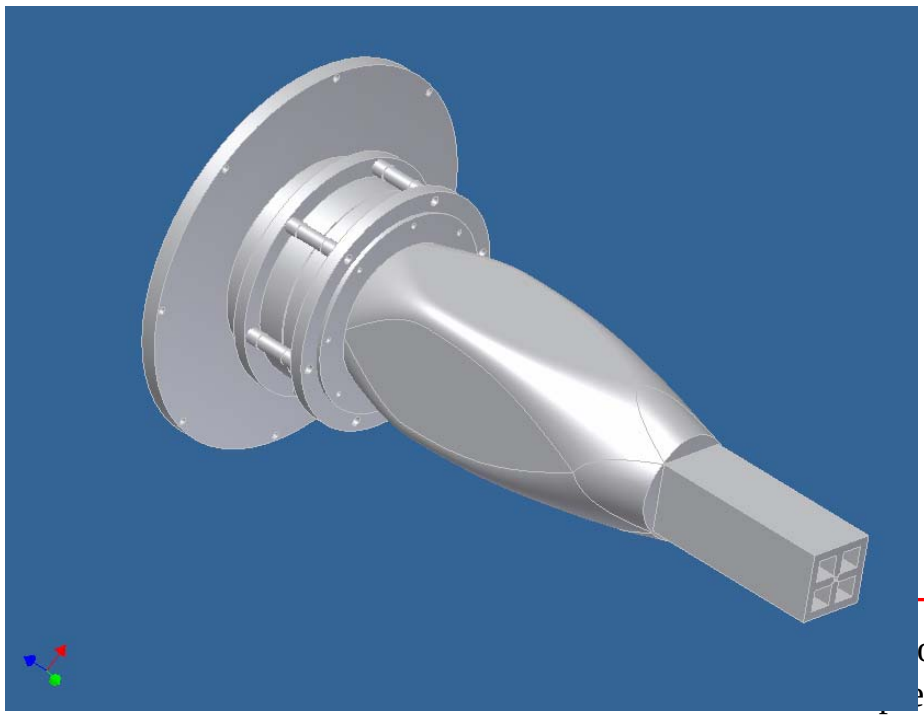
Future Wideband OMT Designs Short-Term Development Effort *S-Band*

- To get the S-Band OMT development back on track, we were able to acquire the "loan" of Mike Stennes from the GBT for a 2 year period
- While Stennes will remain in Green Bank, he will devote 80% of his time to OMT development for the EVLA (and will be on the EVLA budget)
- Phase I of the Stennes Work Package includes:
  - **Scaling the 1-2/4-8 GHz designs to 2-4 GHz using HFSS & CST**
  - **With Dinwiddie, design a Prototype OMT and evaluate its performance**
  - **Determine modifications to convert the old VLA L-Band dewar into the new EVLA S-Band receiver**
  - **Cryogenic tests of the Prototype OMT**
  - **With Dinwiddie, design an affordable "Production" 2-4 GHz OMT**
  - **Evaluate performance of the final OMT Test Article**
  - **Target date to enter EVLA S-Band Production is 2008 Q3**



Stennes
S-Band OMT

- Simulated with HFSS & CST
- Top Level 3-D Inventor Drawings complete
- Start machining Prototype OMT 2007-Q4
- Evaluate Prototype OMT 2008-Q1
- Re-use VLA L-Band dewars



Future Wideband OMT Designs Long-Term Development Effort

X-Band - Constraints

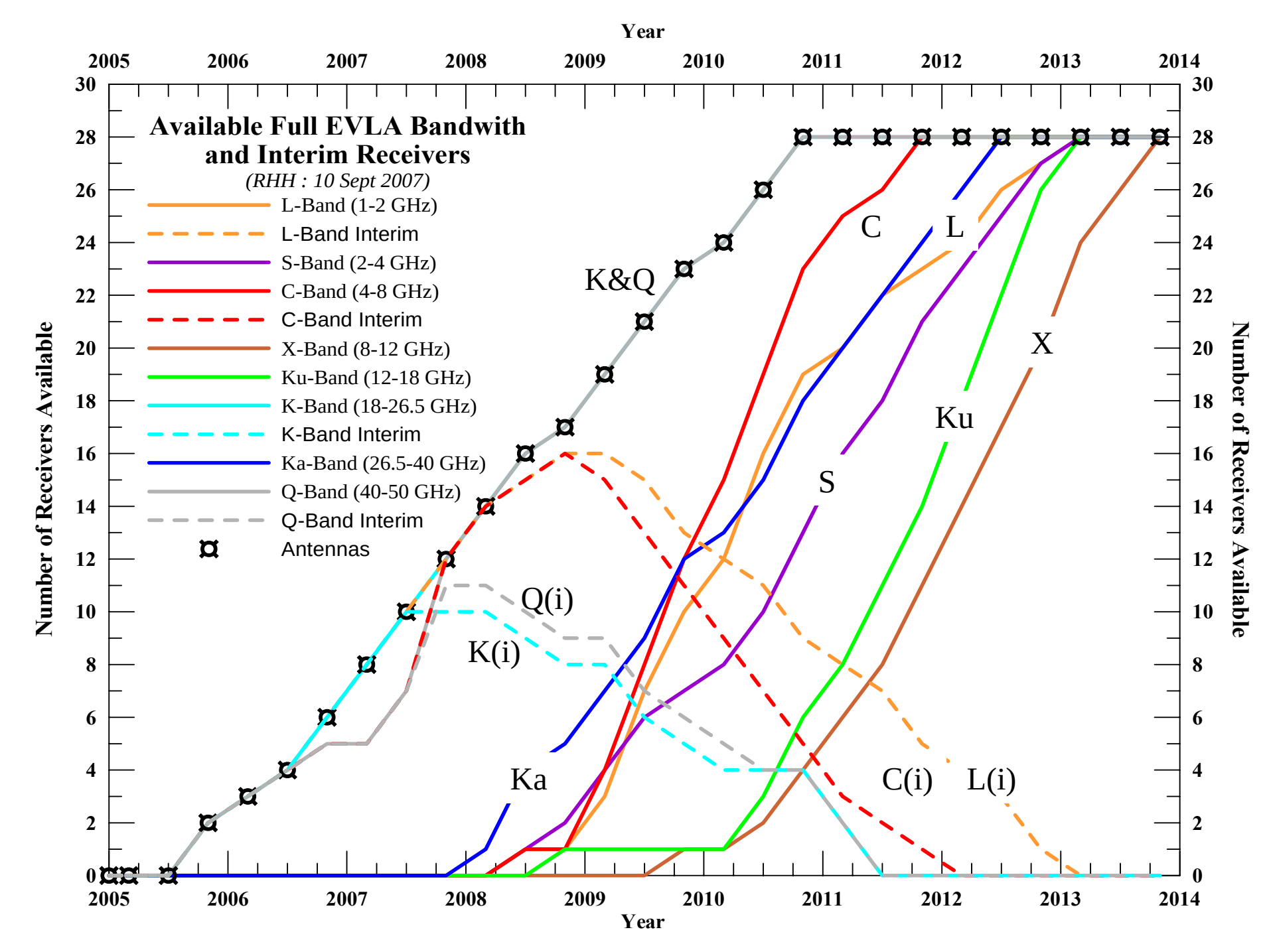
- The 8-12 GHz polarizer needed for the X-Band receiver presents us with several design problems:
  - **Quad-ridge OMT will likely be impractical (very small coaxial probes)**
  - **Waveguide phase-shifter & OMT would be too large (~20" long) & hard to cool**
- The current VLA X-Band dewar uses a Model 22 fridge and we would prefer to use it rather than a new beefier Model 350
  - **Each EVLA Antenna's 3 compressors can cool two Model 350's plus a Model 22 but not three Model 350's**
  - **If the X-Band Rx needs a 350, then we have to add a 4th compressor (~$250K) or modify one of the compressors for extra capacity (~$30K) at the risk of reduced reliability**
- **The ideal solution would be to have the new wideband polarizer fit inside the existing X-Band dewar with minimal modifications**
  - **Next best would be to have a design that might require a new taller or fatter dewar but still allow us to reuse the Model 22 fridge**

Future Wideband OMT Designs Long-Term Development Effort
X-Band - Solutions

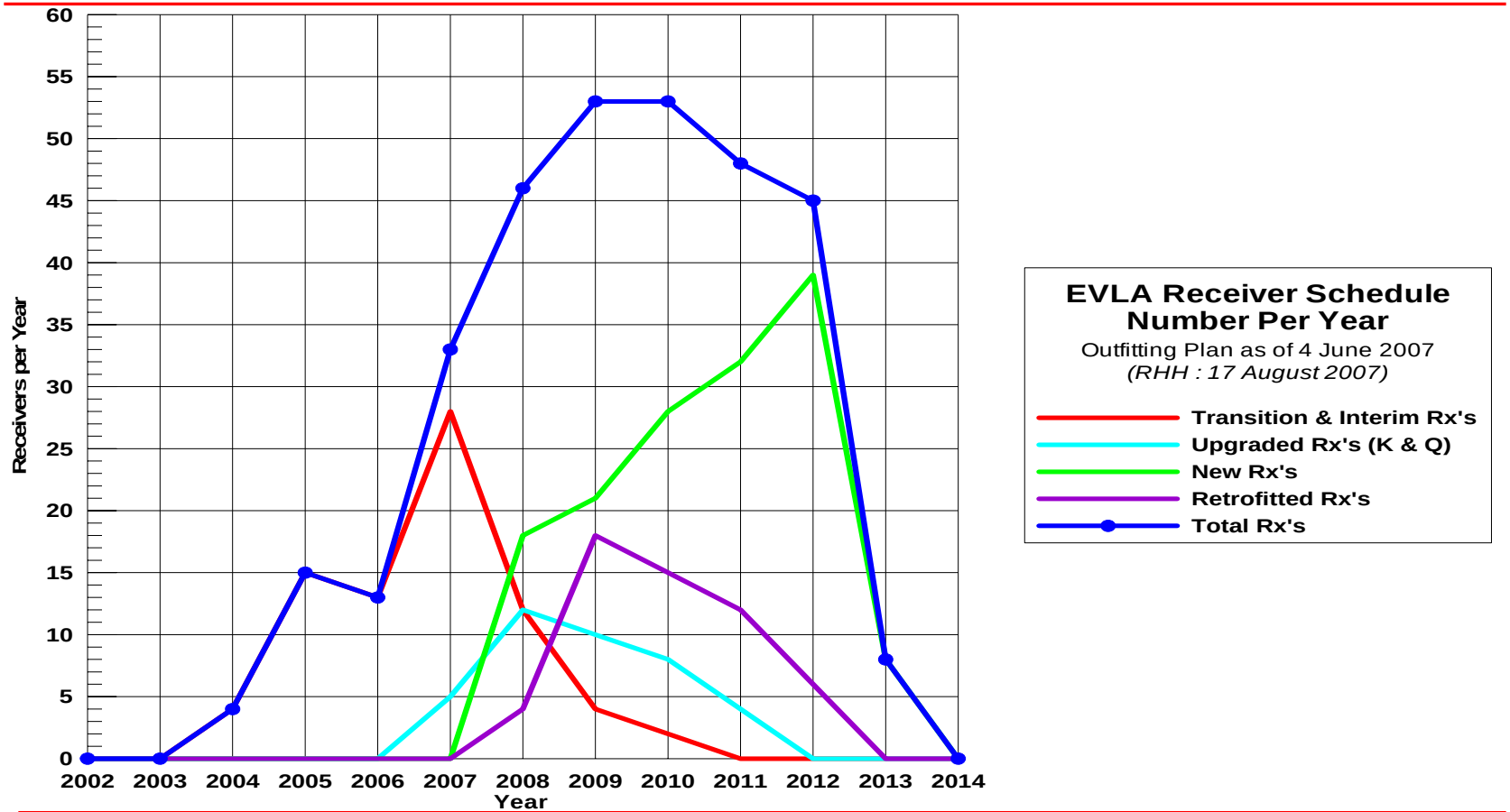
- The bulk of the X-Band OMT development effort has been farmed out to our NRAO sister labs:
  - At the CDL, Srikanth will investigate an all-waveguide solution
    - **Possibly based on the Mitsubishi turnstile junction design**
  - At Green Bank, Phase 2 of the Work Package has Stennes attempting to develop a planar OMT
    - **Design replaces the coaxial probes with a microstrip circuit and has two 180° hybrid couplers to combine the signals from the opposing probes**
    - **Likely to be rather lossy but allows the 90° hybrid (needed to create circular polarization) and Cal Coupler to be fabricated on the same circuit board**
    - **Possibly competitive with other designs & easier to phase-match**
- By the middle of 2009 we should be in a position to select the design that best meets both our performance requirements and physical constraints

Receiver Production
Delays & Recovery Efforts

- We have addressed several issues that have caused delays in the receiver production schedule:
  - Longer than planned to develop L & C-Band OMTs
    - Successful prototypes and future development of S-Band farmed out
  - Loss of RF engineering expertise in 2006
    - New microwave engineer hired (Coutts) & Stennes on-board in GB
  - Fabrication problems with Q-Band MMIC post-amp
    - Units re-worked and no further assembly issues expected
  - Extended ramp-up of new Card Cage unit delayed C-Band
    - New EVLA Card Cage finally in mass-production


Available Full EVLA Bandwith
and Interim Receivers
(RHH : 10 Sept 2007)
L-Band (1-2 GHz)
L-Band Interim
S-Band (2-4 GHz)
C-Band (4-8 GHz)
C-Band Interim
X-Band (8-12 GHz)
Ku-Band (12-18 GHz)
K-Band (18-26.5 GHz)
K-Band Interim
Ka-Band (26.5-40 GHz)
Q-Band (40-50 GHz)
Q-Band Interim
Antennas
K&Q
Q(i)
K(i)
Ka
C
L
S
Ku
X
C(i)
L(i)
Year
Number of Receivers Available
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

Number of Front-Ends Required Annually

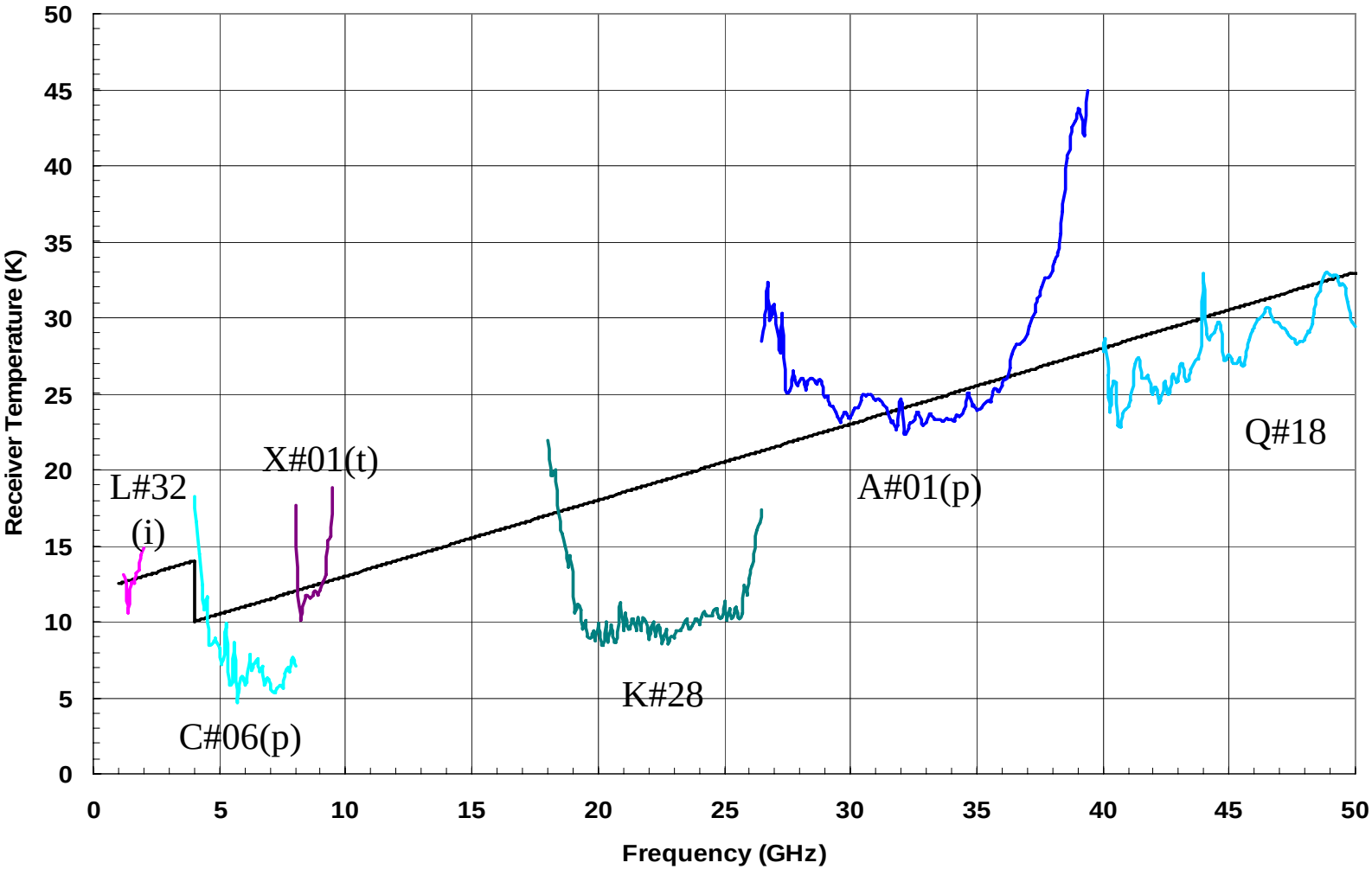


Receiver Production
Issues

- Outfitting schedule calls for about 6 Antennas per year through 2010
- At the peak period (2008-2012) will have to build over 40 receivers per year
- Level of effort depends on the type of receiver:
  - **Transition X-Band merely needs SOIDA testing**
  - **Upgraded K & Q much simpler than building a new receiver**
  - **Retrofitting Interim C, K & Q-Band are even easier**
  - **Recycling old L-Band dewar into new S-Band receiver also saves time**
  - **New C, L, Ku, X-Band will require the most effort**
- Assuming all the purchased and machined components are on-hand…
  - Expect one technician can build a receiver in 4 to 6 weeks
  - 1 tech should be able to build between 8-12 receivers in one year
  - 5 techs to be able to build 40-60 receivers a year
  - Rest of the 9 available techs needed to address:
    - **VLA/VLBA/EVLA maintenance.**
    - **VLA Antenna stripping & EVLA Antenna out-fitting.**
    - **Circular Waveguide maintenance.**

VLA/EVLA

Receiver Temperature Performance vs. Frequency

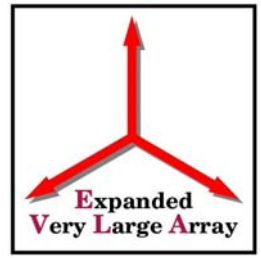


Project Book	
Band	T_{Rx} (°K)
L	14
S	15
C	16
X	20
Ku	25
K	34
Ka	40
Q	48

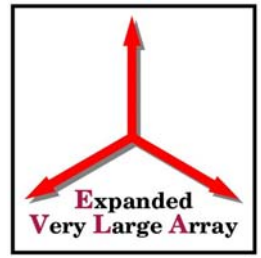
$T_{Rx} = m \cdot F + b$; m = 0.5°K/ GHz ; b = 10°K (L & S) or 8°K (C, X, Ku, K, Ka & Q)

Receiver Production
Summary

- OMT development effort is once again on-track
- FE staffing levels appear adequate to meet our demanding production goals
- Development of L, S & C-Band OMTs should be complete by end of 2007 and early 2008
- 2008 will see new EVLA-compliant L, S, C & Ka-Band receivers begin to enter production
- **Low-Noise Amplifier deliveries from CDL have been meeting or exceeding our receiver schedule**



Questions ?



Backup Slides

VLA versus EVLA

Frequency Coverage & Feeds

Band	VLA		EVLA	
	Freq (GHz)	Feed Horn Type	Freq (GHz)	Feed Horn Type
L	1.35 - 1.75	Lens + Corrugated	1 - (1.2) - 2	Compact Corrugated
S			2 - 4	Compact Corrugated
C	4.5 - 5.0	Lens + Corrugated	4 - 8	Compact Corrugated
X	8.0 - 8.8	Linear Taper Corrug	8 - 12	Linear Taper Corrug
Ku	14.4 - 15.4	Pyramidal	12 - 18	Linear Taper Corrug
K	18 - 26.5	Linear Taper Corrug	18 - 26.5	Linear Taper Corrug
Ka			26.5 - 40	Linear Taper Corrug
Q	40 - 50	Linear Taper Corrug	40 - 50	Linear Taper Corrug

EVLA Receivers System Overview

Band	"L"	"S"	"C"	"X"	"Ku"	"K"	"Ka"	"Q"
Frequency (GHz)	1-(1.2)-2	2 – 4	4 – 8	8 – 12	12 – 18	18–26.5	26.5 – 40	40 - 50
T(Sys) (°K)	26	26	26	30	37	59	53	74-116
T(Sky) (°K)	12	12	10	10	12	25	13	26 - 68
T(Rx) (°K)	14	14	16	20	25	34	40	48
Polarizer Type	QR+Hyb	QR+Hyb	QR+Hyb	TBD	PS+WB	PS+WB	PS+WB	SS
LO Frequency (GHz)	N/A	N/A	N/A	N/A	N/A	15–18	12–16.7	16.7-20
LO Multiplier	N/A	N/A	N/A	N/A	N/A	x 2	x 3	x 3
Frequency Output	1 – 2	2 – 4	4 – 8	8 – 12	12 – 18	8 – 16.5	8 – 18	8 - 18
Output Power (dBm)	-38	-35	-34	-32	-35	-38	-35	-38
Headroom $P_{1\%}$(dB)	40	38	33	29	27	23	21	15
Output to Module	T302	T302	T302	T304	T303	T303	T303	T303
Refrigerator Model	1020	350	350	22 ?	350	350	350	22

Overview Table Notes

T(Sky) (°K) : **A**ntenna & atmosphere contribution when pointed at zenith in dry winter weather. Includes 3°K cosmic background

T(Rx) (°K) : Averaged across full band, assumes LNA noise temperature of
- 4°K below 4 GHz (Balanced Amplifiers)
- 1°K/GHz 4-8 GHz & 0.5°K/GHz above 8 GHz.

Polarizer Type : All dual circular polarization.
- "QR+Hyb" = quad-ridge OMT followed by a 90° hybrid.
- "PS+WB" = waveguide Srikanth Phase Shifter followed by Wollack's implementation of a Bøifot class IIb OMT.
- "SS" = Sloping Septum polarizer.

LO Multiplier : The LO frequencies are multiplied by this factor in the receiver.

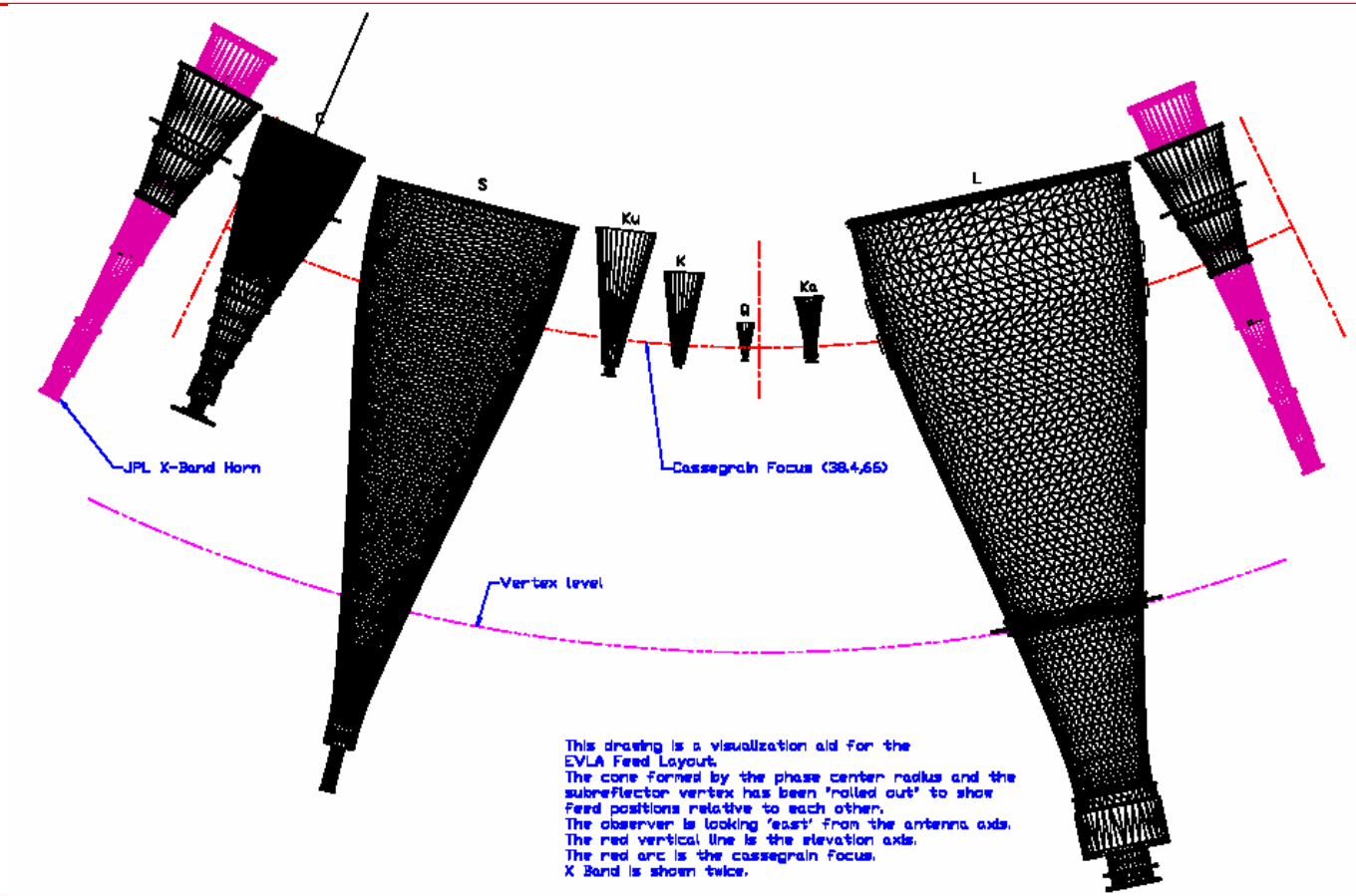
Output Power : Total power contained in the output band specified while observing "cold sky" at zenith over the specified bandwidth.

Headroom : With respect to the 1% compression point when on "cold sky".

Output to Module : RF/IF signal from receiver feeds the designated frequency converter module: T302 = LSC Converter , T303 = UX Converter , T304 = Down-Converter

Refigerator Model : CTI Incorporated model numbers.

EVLA Feeds Rolled Out View

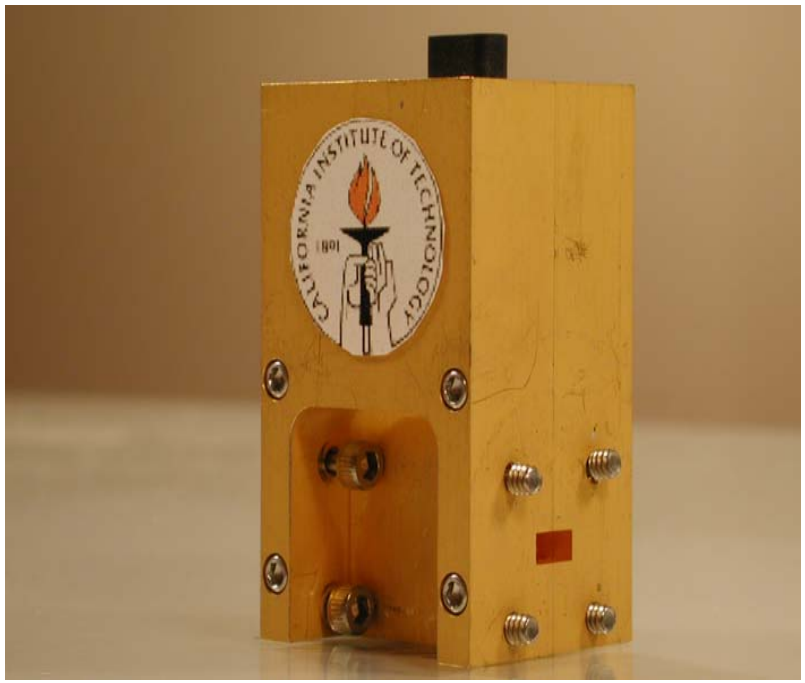


EVLA Q-Band

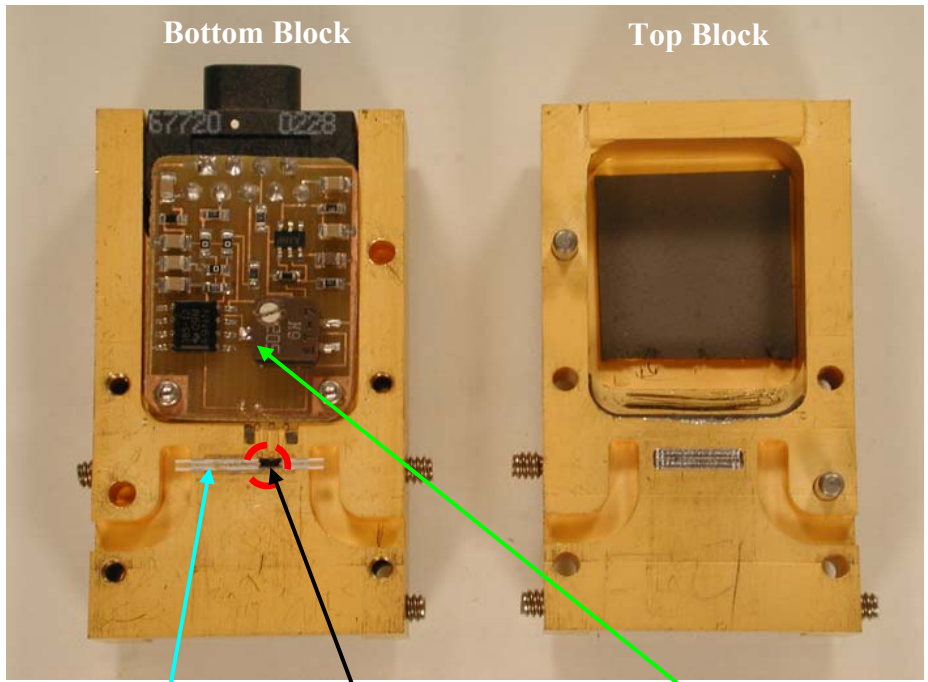
Q-Band Post-Amp Module (Q-PAM)

(Prototype units designed & built at Caltech)

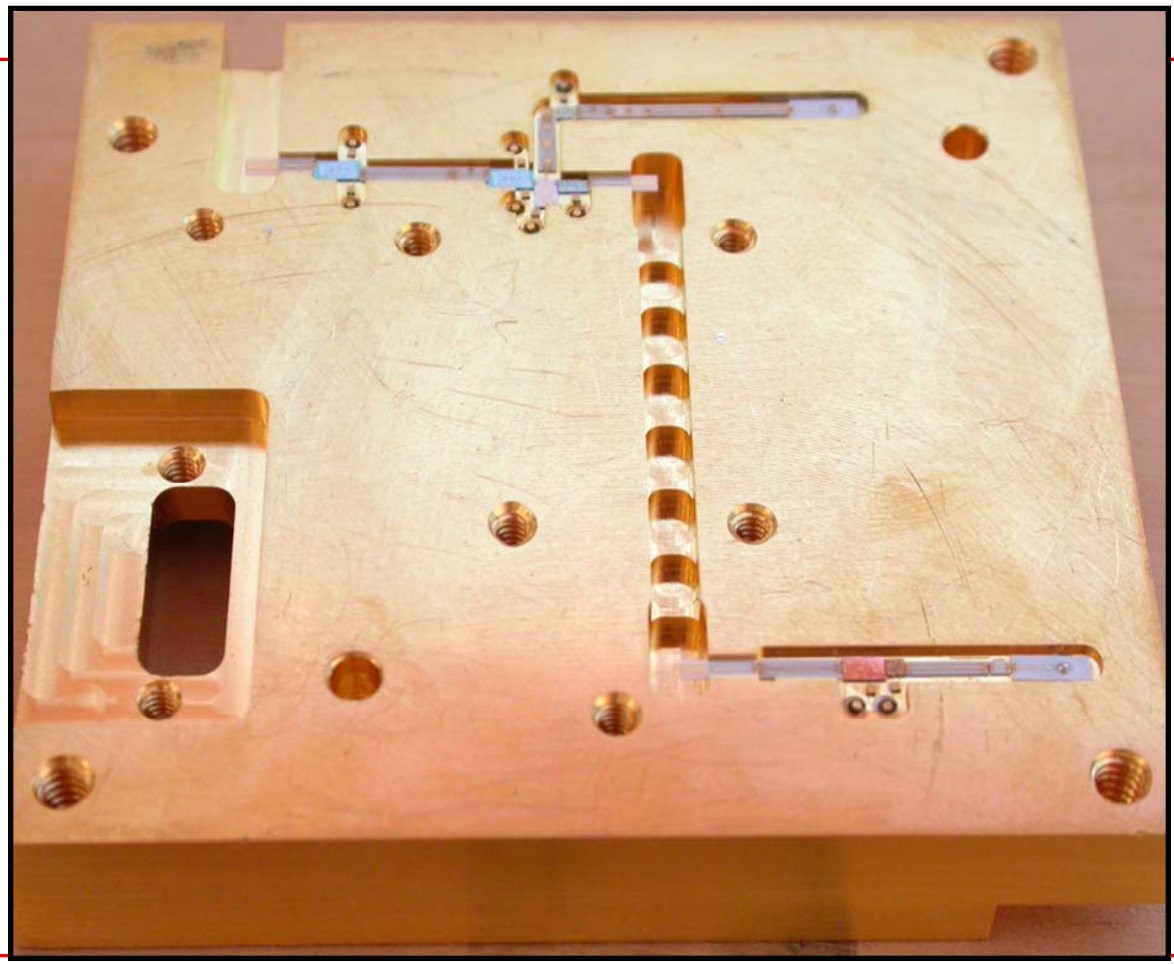
Assembled Module



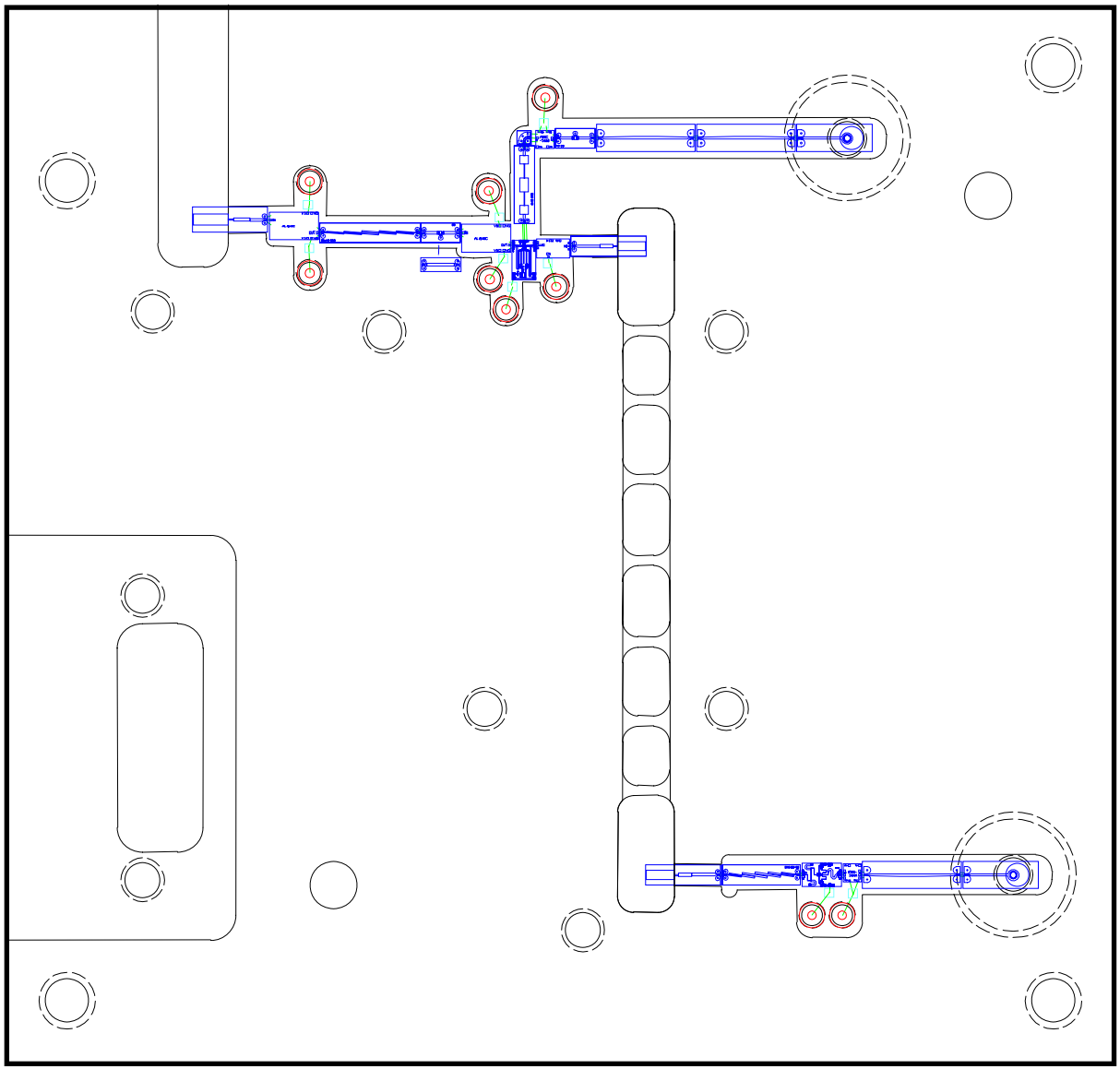
Disassembled Module



KaDCM MMIC Channels & LO Filter



EVLA KaDCM



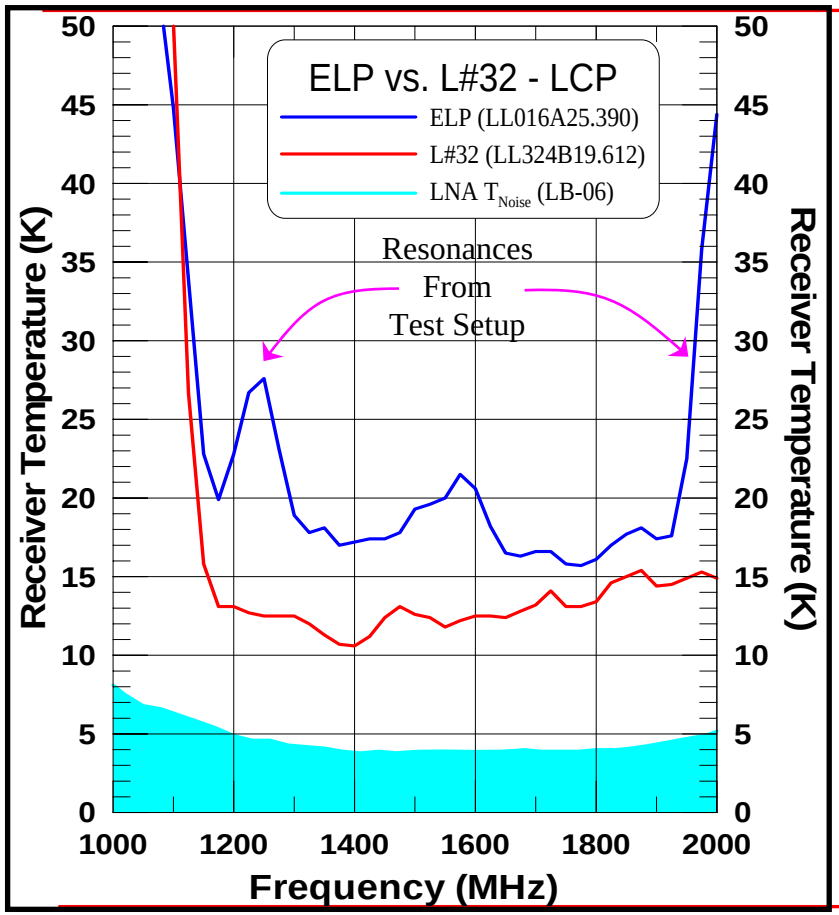
Co-Planar W/G Circuit Board & MMIC Component Layout

The KaDCM contains:

- 7 MMIC Devices
  - 5 Amplifiers (Agilent)
  - 1 Custom Mixer (UMS)
  - 1 Custom Tripler (UMS)
- 14 CPW boards
- Approx 75 wire bonds

EVLA L-Band Prototype (ELP) vs. Interim L#32

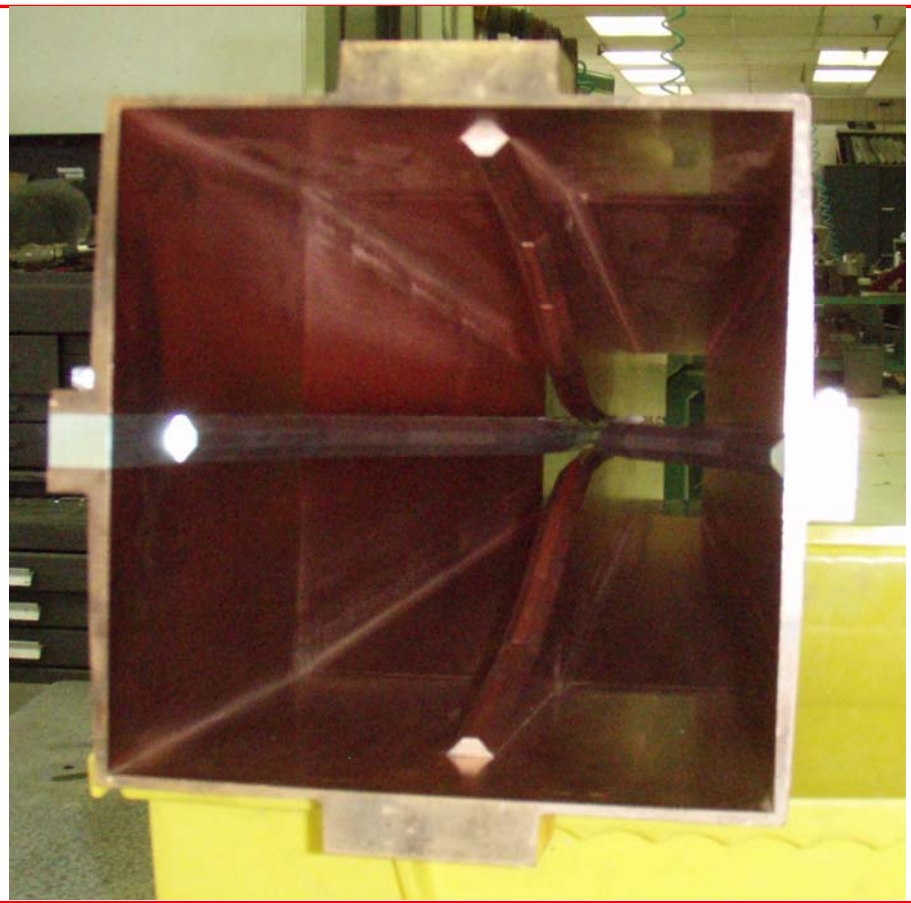
Using Narrowband Hot/Cold Test Load Zotefoam Vacuum Windows



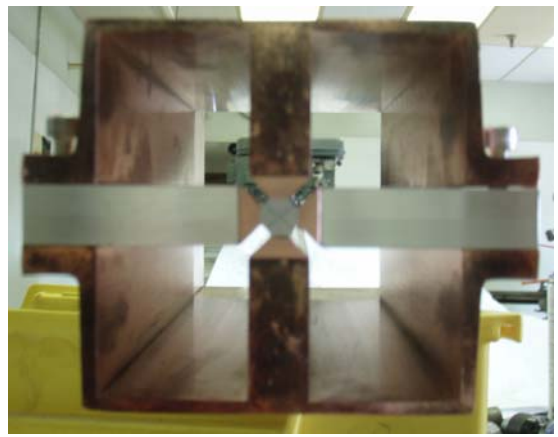
- L#32 Interim receiver's OMT had a physical temperature of about 45K
- After lengthy struggle, temperature of the ELP OMT was reduced from about 110K down to less than 60K
- Broad bump near 1250 MHz and sharp spike near 2000 MHz are due to resonances in the lab H/C test setup
- Lab H/C Loads have poor match below 1200 MHz (using an old VLA OMT)
- Sensitivity of new OMT is 5K worse than we would like. Cu-plating the fins should reduce the insertion loss

L-Band Production OMT

First Test Article with Electroformed Throat Mandrel



Mouth



Throat

FE Staff

- EVLA Front-End & Feed Systems Management:
  - **Level 2 Task Leader - Bob Hayward**
    - **FE Group Leader - Chuck Kutz**
    - **Receiver Production - Brent Willoughby**
    - **Mech Eng Support - Hollis Dinwiddie**
    - **Cryogenics - Rudy Latasa**
    - **Feeds - Jim Ruff**
- Staff available for EVLA Front-End effort:
  - **At AOC : 3 RF engineers [Hayward, Kutz, Coutts + Mertely (@ 10-20%)]**
    3 Mechanical engineers [Dinwiddie, Ruff (@ 40%) + New ME]
    9 electronic technicians & technical specialists
  - **At CDL : EM : Srikanth (design of Ku & X-Band waveguide components)**
    LNAs : Amplifier Group + 2 techs (paid by EVLA through 2010)
  - **At GB : Stennes (S & X-Band OMTs)**

Receiver Production
Optimization of Effort

- We are also optimizing FE staff effort by:
  - **Designing receiver sub-systems which are compatible with mass production concepts.**
  - **Maximizing outsource options, including Cryo Group & VLBA Sites.**
  - **Ensuring machined parts are available when needed by utilizing Green Bank and external machine shops.**
  - **Using production-line techniques for new receivers.**
- Also expect less & less maintenance required on old VLA modules as more old antenna electronics retired
  - **LO modules (F3 & F12) & IF modules (F4, F6 & F9's).**
  - **Have enough spares now that old VLA FE modules will never have to be repaired ever again.**
  - **This will free up extra manpower (although we'll obviously have more & more receivers that can break and need to be repaired).**
  - **On EVLA, all the LO & IF converters are the responsibility of the LO/IF Group.**

Estimated EVLA L-Band T_{Rx}, Output Power & Headroom

EVLA L-Band Rx (RHH : 28 March 2006)	P (1dB) (dBm)	P (1%) (dBm)	Temp (K)	NF/C (dB)	Loss/Gain (dB)	Loss/Gain (linear)	Delta T (K)	Tsys (K)	BW (MHz)	Pnoise (dBm) for Tsky of 12.0 (K)	Pnoise dBm/GHz	Headroom (dB)
									2000	-94.8	-97.8	
Weather Window			300		-0.02	0.9954	1.385			-94.3		
Feed Horn			300		-0.05	0.9886	3.490			-93.4		
Vacuum Window			300		-0.001	0.9998	0.070			-93.4		
Quad-Ridge OMT			50		-0.1	0.9772	1.184			-93.2		
Coax Cable			32.5		-0.05	0.9886	0.391			-93.1		
Hybrid Phase Shifter			15		-0.2	0.9550	0.744			-93.2		
Coax Cable			15		-0.05	0.9886	0.191			-93.2		
Cal Coupler (IL)			15		-0.2	0.9550	0.788			-93.2		
Cal Coupler (Branch)			300	-30	0	1.0000	0.300			-93.1		
Isolator			15		0	1.0000	0.000			-93.1		
Balanced LNA (16-20 dB)	-5	-17	4		18	63.0957	4.668	13.21		-74.2		57.2
Coax Cable			15		0	1.0000	0.000			-74.2		
Transfer Switch			15		0	1.0000	0.000			-74.2		
Filter Hi-Q/Notch			15		0	1.0000	0.000			-74.2		
Coax Cable			15		0	1.0000	0.000			-74.2		
Balanced LNA (16-20 dB)	13	1	20		18	63.0957	0.370			-56.2		57.2
Stainless Steel Coax			157.5		-2	0.6310	0.027	13.61		-58.2		
Coax Cable			300		-1	0.7943	0.036			-59.2		
Switch			300		0	1.0000	0.000			-59.2		
Isolator			300		-0.5	0.8913	0.021			-59.7		
Filter (0.8-2.2 GHz)			300		-1	0.7943	0.051		1400	-62.2		
Post-Amp	15	3	229.6	2.5	30	1000.0000	0.190			-32.2		35.2
Isolator			300		-0.5	0.8913	0.000	13.91		-32.7		

Summary of Estimated EVLA Front-End System Temperature, Output Power & Headroom

EVLA Receiver Band	Receiver				T303 UX-Converter				T302 LSC-Converter				T304 Down-Converter						Delta
	T_{Noise} (K)	$T_{@Dewar}$ (K)	P_{Out} (dBm)	Min HR (dB)	T_{Noise} (K)	P_{In} (dBm)	P_{Out} (dBm)	Min HR (dB)	T_{Noise} (K)	P_{In} (dBm)	P_{Out} (dBm)	Min HR (dB)	T_{Noise} (K)	P_{In} (dBm)	P_{Out} (dBm)	DAtt-1 (dB)	DAtt-2 (dB)	Min HR (dB)	T_{Noise} (%)
L-Band	**13.91**	13.61	-32.7	**35.2**					**13.92**	-40.2	-40.2	**23.7**	**14.16**	-47.2	-33.6	*-8.0*	*-10.0*	**27.0**	1.8
S-Band	**14.78**	14.01	-34.3	**36.8**					**14.81**	-41.8	-41.8	**25.3**	**15.05**	-48.8	-32.5	*-3.0*	*-10.0*	**24.8**	1.9
C-Band	**15.34**	14.92	-31.3	**31.0**					**15.37**	-38.8	-38.8	**22.3**	**15.60**	-45.8	-33.2	*-3.0*	*-11.0*	**21.8**	1.7
X-Band	**19.57**	19.15	-32.3	**30.4**									**19.92**	-44.1	-33.0	*-8.0*	*-7.0*	**24.1**	1.8
Ku-Band	**24.86**	24.19	-35.1	**28.2**	**24.92**	-40.1	-31.2	**28.8**					**25.23**	-41.0	-33.0	*-8.0*	*-10.0*	**21.0**	1.5
K-Band	**33.79**	32.35	-36.1	**20.8**	**33.92**	-41.1	-32.2	**29.8**					**34.45**	-42.0	-33.0	*-8.0*	*-9.0*	**22.0**	1.9
Ka-Band	**39.95**	38.89	-34.3	**23.1**	**40.08**	-39.3	-32.9	**28.0**					**40.63**	-42.7	-33.6	*-8.0*	*-9.0*	**22.7**	1.7
Q-Band	**48.43**	46.42	-38.5	**15.5**	**48.84**	-44.3	-36.4	**33.0**					**49.71**	-46.2	-34.1	*-3.0*	*-11.0*	**22.2**	2.6
Goal =				>20		-40		>20		-40		>20		-45	-33			> 20	< 2.0

"Delta T_{Noise}" = Percent Difference between Receiver Noise Temperature at the Sampler Input compared to that at the Receiver Output *Goal = 1% (ie: S/N of 20 dB)*

"Headroom" = Ratio in dB below the 1% Compression Point (typically 12 dB below 1 dB Compression Point) Goal = 20 dB *Goal = 20 dB*