EVLA Front-End CDR

Water Vapor Radiometer Option

Water Vapor Radiometer

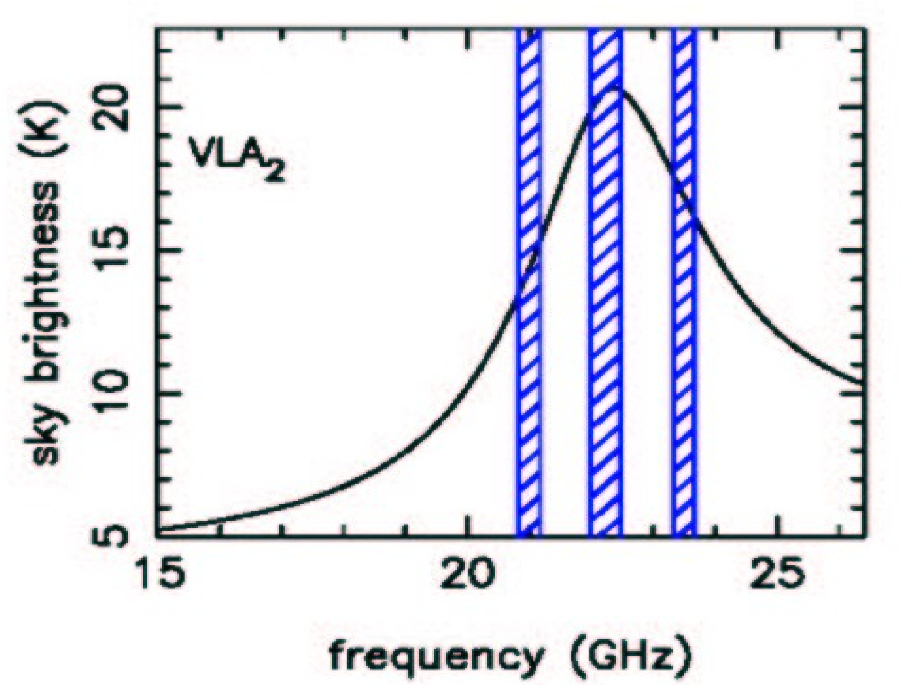
- Development project
- Not in EVLA baseline plans
- If successful, has implications for EVLA

WVR….why?

- Water vapor emission in the atmosphere increases electrical path length resulting in phase fluctuations in the astronomical data
- The effect of these fluctuations is greater at shorter wavelengths
- Measuring fluctuation of the amplitude of water vapor emission at 22 GHz enables a phase correction to be generated and applied to astronomical data

Current WVR system

- The current WVR detection scheme uses three channels centered on the water line
- The bandwidth and frequency of the channels are limited by RFI generated in the present LO scheme

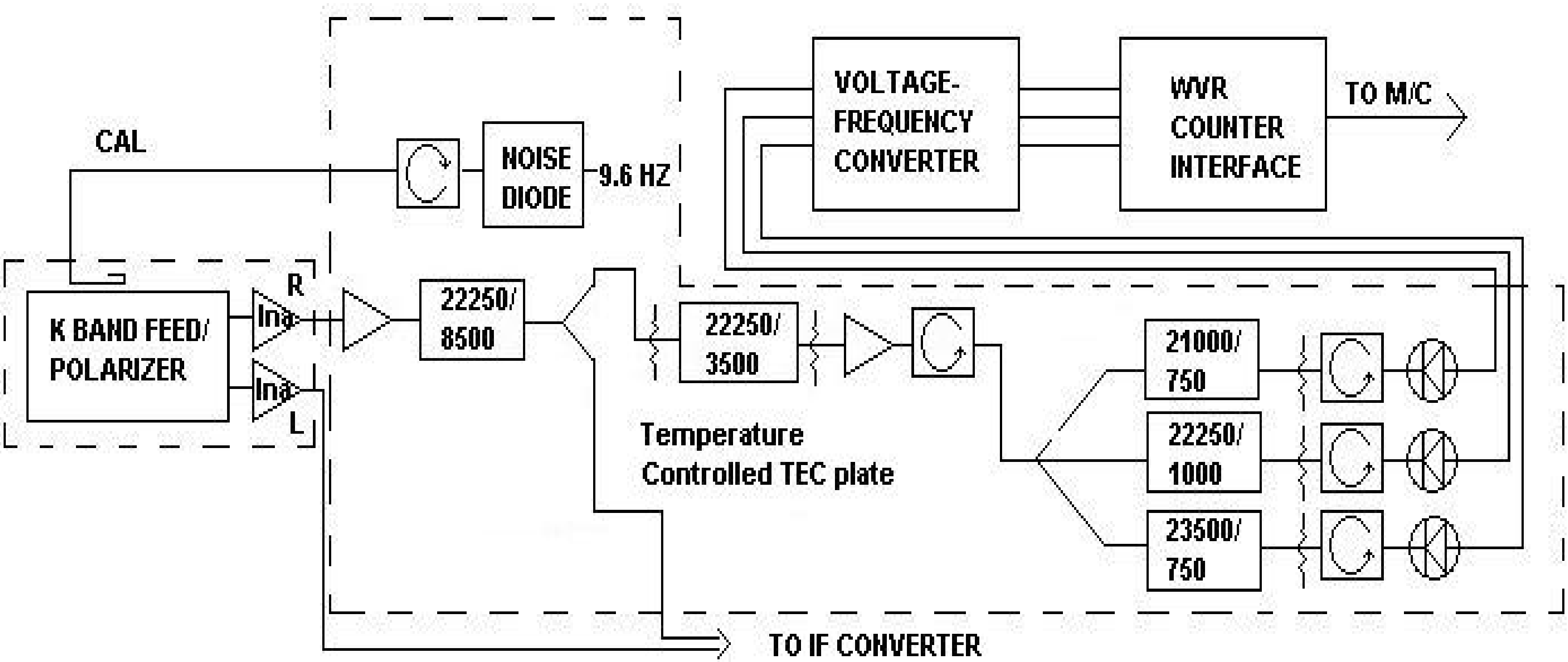


(From Butler 1999)

Scientific Requirements

- Defined by need to measure Q band phase fluctuations to 10 deg rms
- Fractional amplitude stability of 10^{-4}
- Timescales 2 sec to 30 min

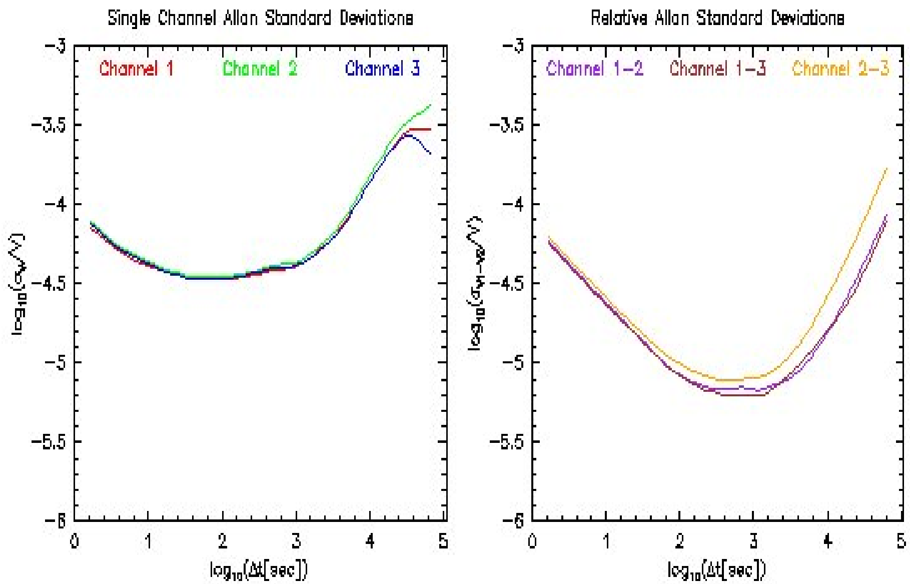
VLA WVR block diagram

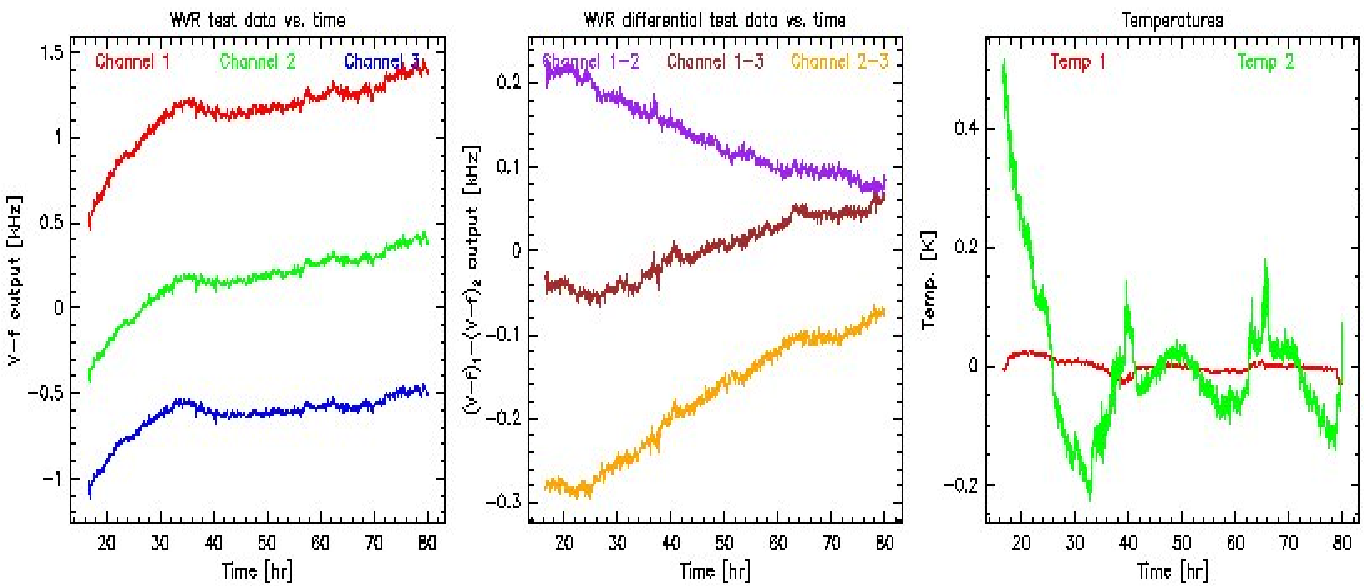


File = 0119ND
Averaging time = 113.88 sec
Channel 1 mean = 292.839 kHz
Channel 2 mean = 220.284 kHz
Channel 3 mean = 218.547 kHz
Temp. 1 mean = 294.964 K
Temp. 2 mean = 289.025 K
Time range: 16.6 to 80.0 hours
Mode : Ave(Off Data, On Data)

Notes:

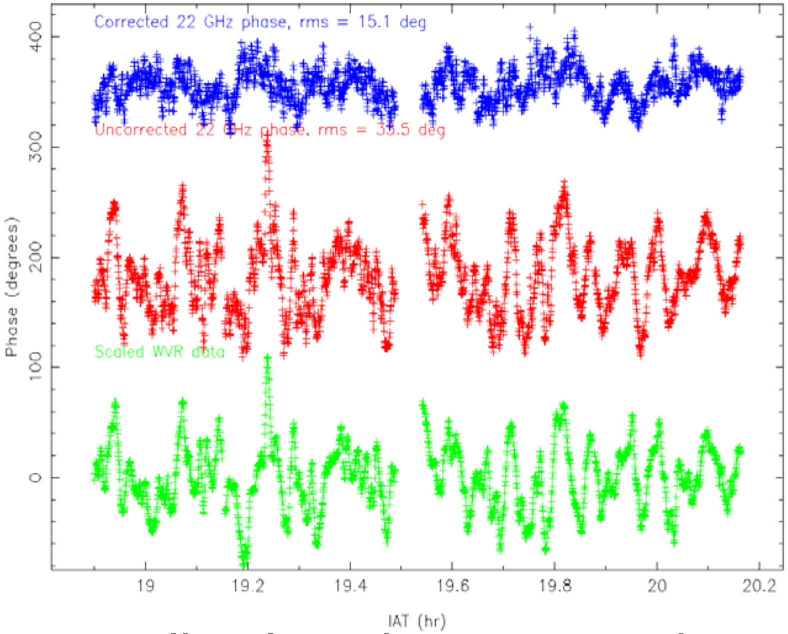
Noise Diode as source
Changed temp setpoint
V-F #2
Temp #1 is RF plate
Temp #2 AOC lab ambient



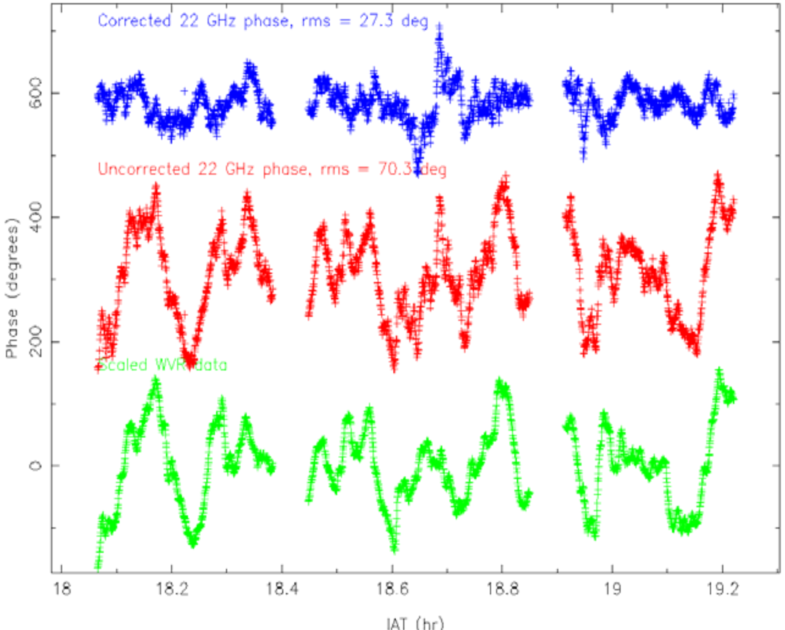


WVR prototype stability measurements, using a K band noise diode as source

Correlation between phase and WVR output for two VLA antennas



Baseline length = 800 m, sky clear, 22 GHz



Baseline length = 2.5 km, sky cover 50-75%, forming cumulus, 22 GHz

*BLUE: Phase corrected using the scaled WVR output
*RED: Uncorrected phase
*GREEN: Scaled WVR output

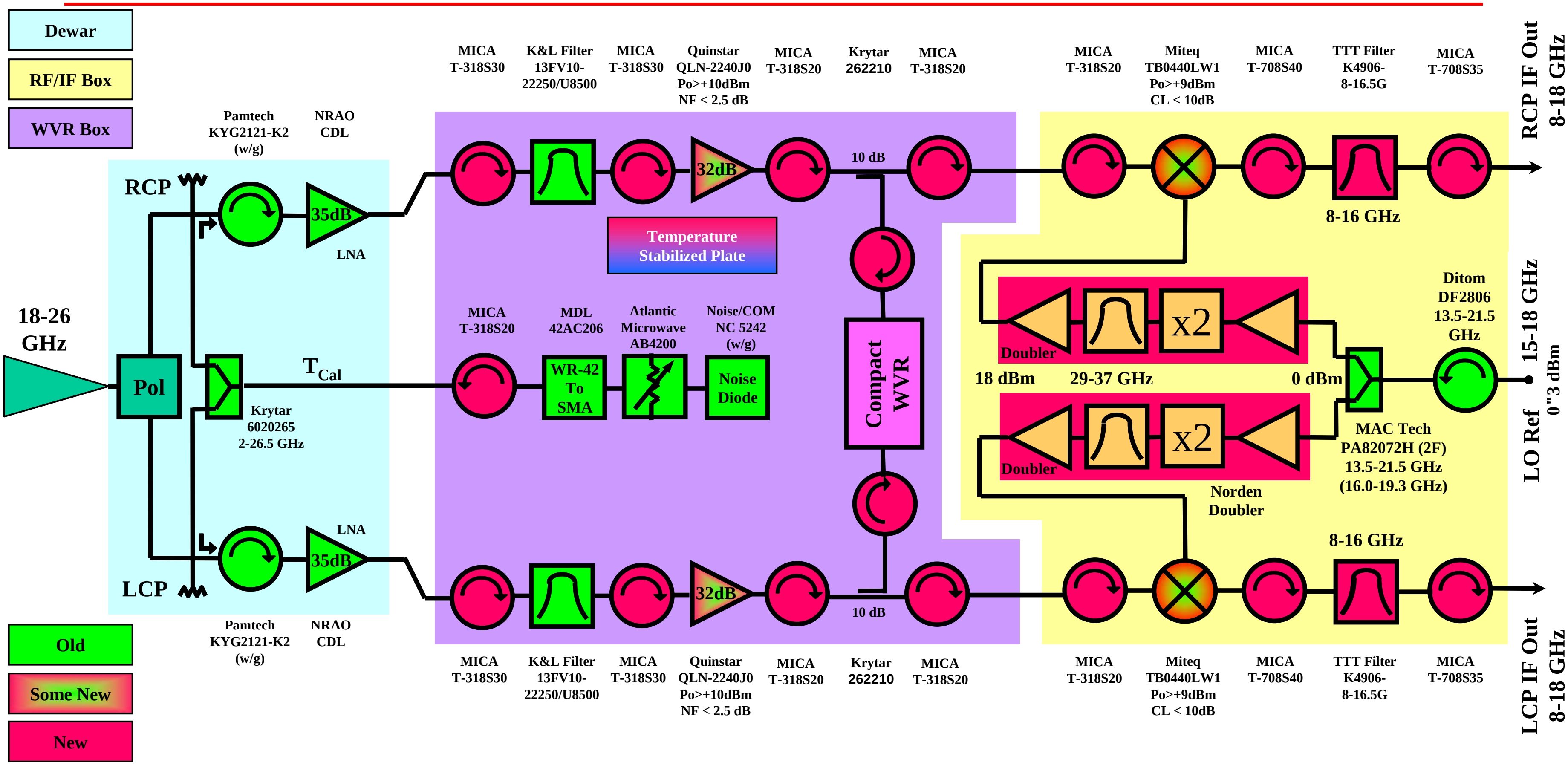
EVLA Compact WVR
Prototype Module

- The Compact WVR concept uses an integrated module with MMIC and drop-in devices (amps, switches, detectors) and microstrip filters
  - Cheaper than a connectorized version
  - Smaller size & less mass
  - Better thermal stability
  - Easier to mass produce
  - More frequency bands (5 filters rather than 3)
  - "Dark Current" switch allows DC offsets to be determined
  - Input switch allows selection between LCP & RCP signals or between Rx & a Termination (or Noise Source) for calibration

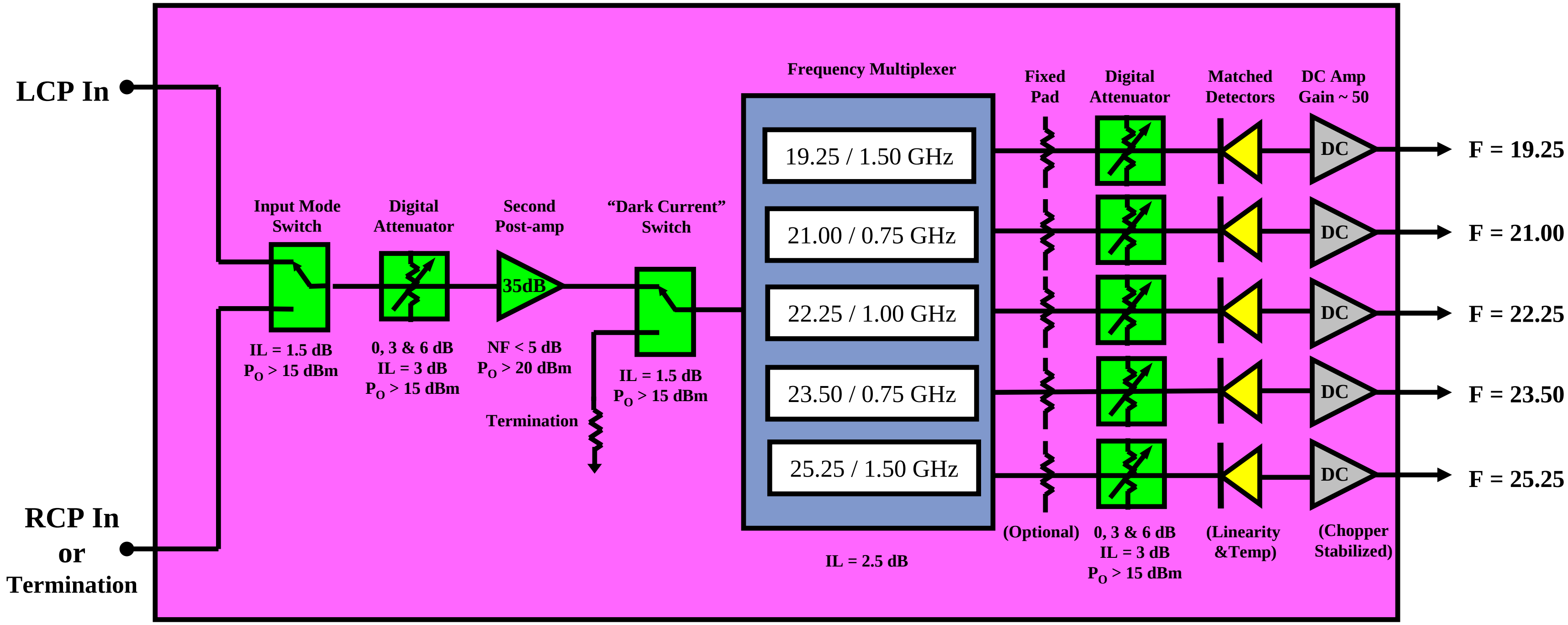
CWVR MMIC

- 15 MMIC chips
- 23 chip caps
- 7 circuit substrates
- 110 wire bonds
- 30% initial savings vs. connectorized version

EVLA K-Band with Compact WVR
(Multiplexed Dual Channel)



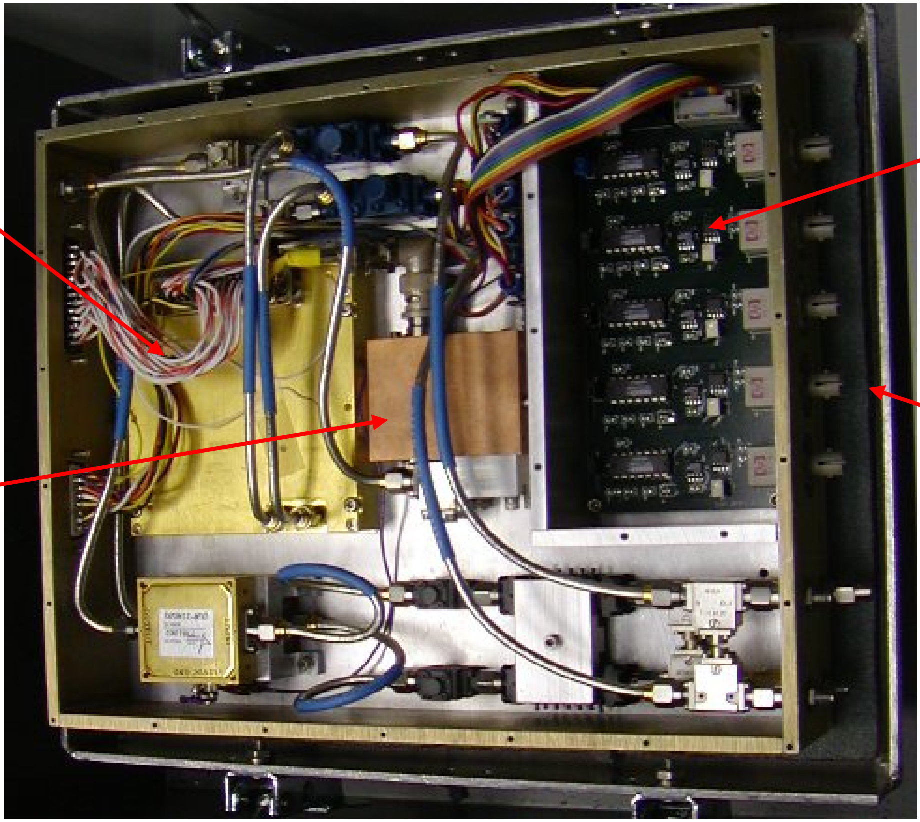
Prototype Compact WVR



Matt Morgan's MMIC Module

MMMMICM

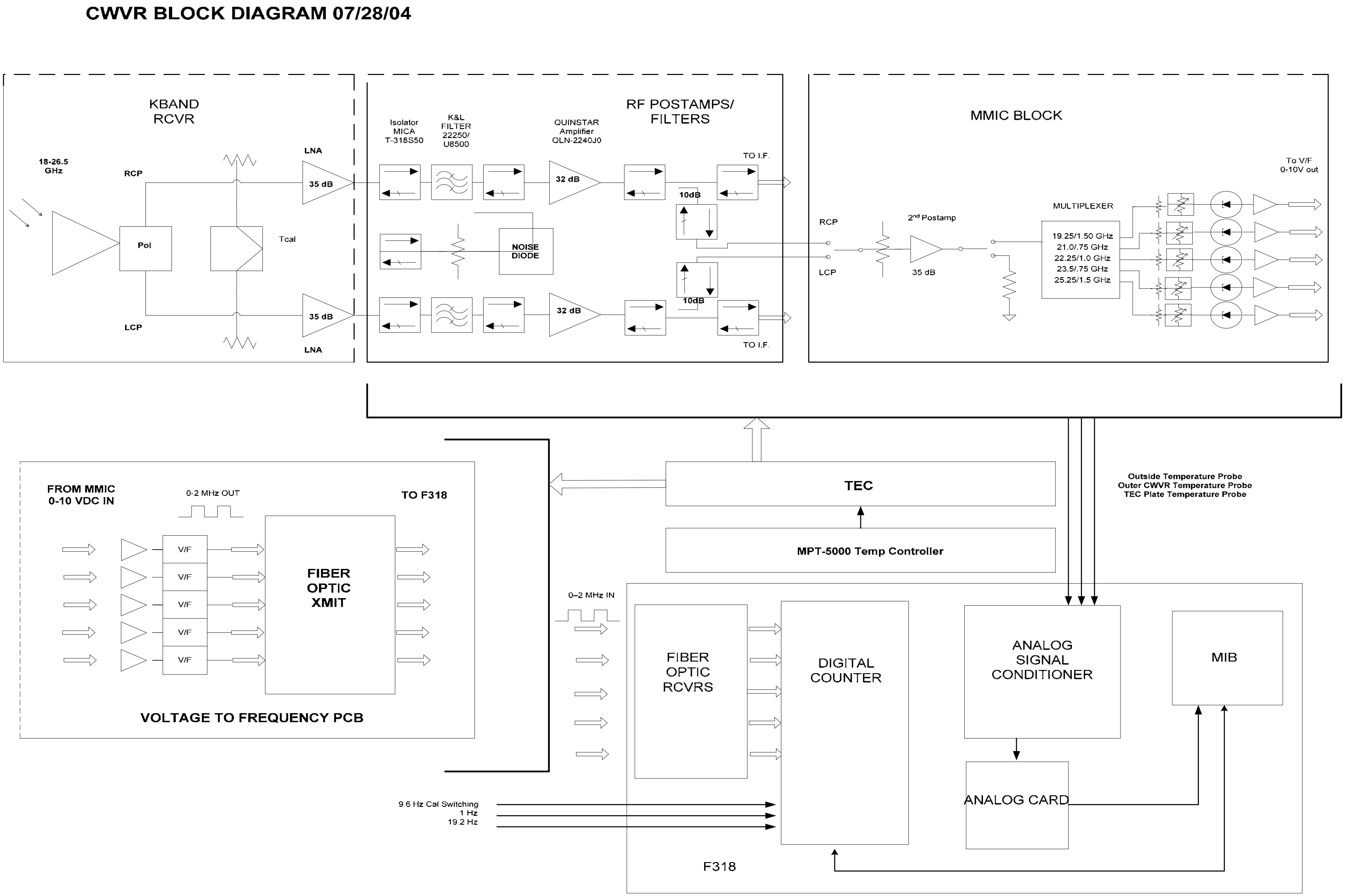
5 channel V-F



Noise Diode

FIBER OUTPUTS

EVLA CWVR


CWVR BLOCK DIAGRAM 07/28/04
KBAND
RCVR
18-26.5
GHz
RCP
LCP
Pol
Tcal
LNA
35 dB
35 dB
LNA
RF POSTAMPS/
FILTERS
Isolator
MICA
T-318S50
K&L
FILTER
22250/
U8500
QUINSTAR
Amplifier
QLN-2240J0
32 dB
32 dB
NOISE
DIODE
10dB
10dB
TO I.F.
TO I.F.
MMIC BLOCK
RCP
LCP
2nd Postamp
35 dB
MULTIPLEXER
19.25/1.50 GHz
21.0/.75 GHz
22.25/1.0 GHz
23.5/.75 GHz
25.25/1.5 GHz
To V/F
0-10V out
FROM MMIC
0-10 VDC IN
0-2 MHz OUT
TO F318
V/F
V/F
V/F
V/F
V/F
FIBER
OPTIC
XMIT
VOLTAGE TO FREQUENCY PCB
TEC
MPT-5000 Temp Controller
Outside Temperature Probe
Outer CWVR Temperature Probe
TEC Plate Temperature Probe
0–2 MHz IN
FIBER
OPTIC
RCVRS
DIGITAL
COUNTER
ANALOG
SIGNAL
CONDITIONER
MIB
ANALOG CARD
9.6 Hz Cal Switching
1 Hz
19.2 Hz
F318

EVLA K-Band

Impact of WVR on Rx

Performance (with T_{LNA}=10°K)

T(LNA) = 10K

	Dewar	Receiver Output			RF Box	WVR		
	Tn (K)	Tn (K)	P (dBm)	HR (1%) (dB)	Adds (K)	Tn (K)	P (dBm)	HR(1dB) (dB)
EVLA K-Band Rx - No WVR	**21.22**	**22.56**	**-37.0**	**21.2**	**1.35**	**-**	**-**	**-**
EVLA K-Band Rx - With Compact WVR	**21.22**	**22.57**	**-39.0**	**22.2**	**1.35**	**22.67**	**-27.5**	**23.2**
Required Spec	**-**	**-**	**-40.0**	**> 20**	**-**	**-**	**-25.0**	**> 16**

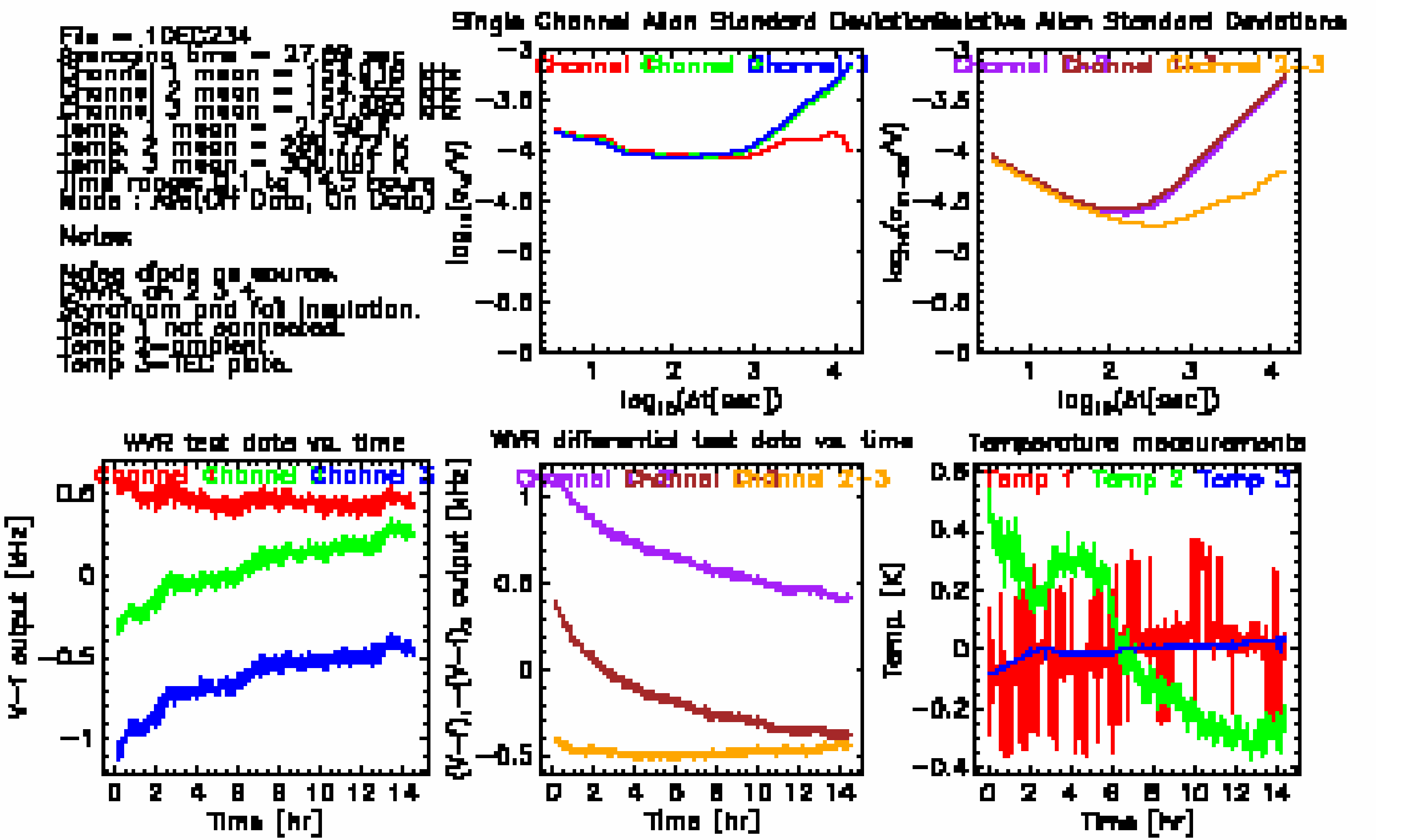
Delta Tn (wrt to Trx) = Percent Difference between Noise Temperature at the Sampler Input compared to that at the Receiver Output
Goal = 1% (ie: S/N of 20 dB)

Delta Tn (wrt to Dewar) = Percent Difference between Noise Temperature at the Sampler Input compared to that at the Dewar Output
Goal = < 5%

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

Headroom (WVR) = Ratio in dB below the 1 dB Compression Point

Preliminary CWVR data



Future CWVR plans

- Continue evaluating MMIC module in the lab using a noise source and then a K band receiver
- Evaluate RFI environment in an EVLA antenna to determine filter bandpasses
- Design/Test 5 channel MIB interface
- Contingent on funding and manpower