EVLA Antenna and Array Performance

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System Requirements

- EVLA Project Book, Chapter 2, contains the EVLA system requirements.
- For most, astronomical tests are necessary to determine if the array meets requirements.
- In previous EVLA Adv. Com. Meetings, I presented selected highlights showcasing the technical developments.
- For this meeting, a more comprehensive review of system performance is presented.

Pointing Targets*

- Blind:
  - Under optimum conditions, (nighttime, calm), the difference between commanded and actual shall be:

    6” RSS, between elevations of 30 and 70 degrees
- Referenced:
  - To a source within 5 degrees and 15 minutes (time):

    3” RSS, between elevations of 30 and 70 degrees
- OTF (On The Fly, or Super-Sidereal Tracking)

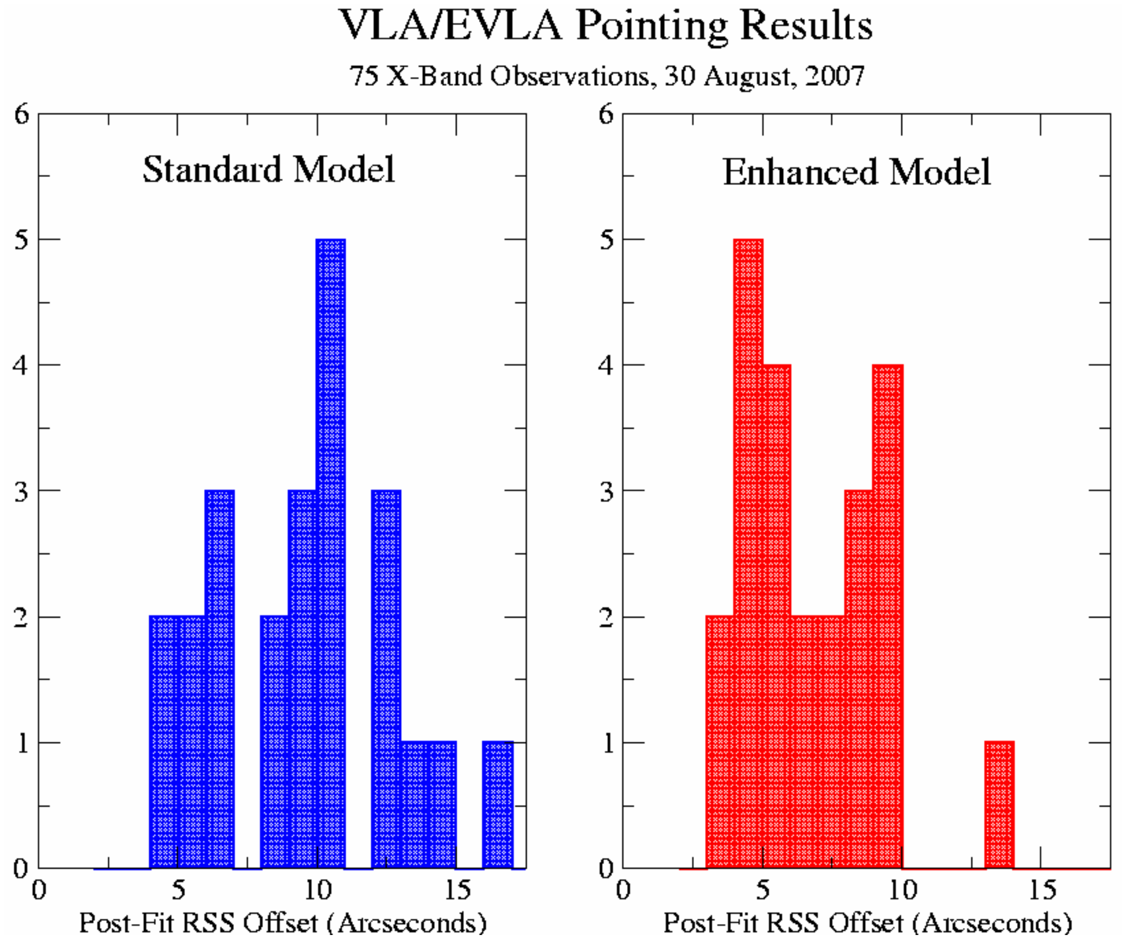
  4” at drive rates up to 1 deg/min

  8” at drive rates of 1 to 2.5 deg/min.

* Improved pointing is an Operations responsibility.

VLA/EVLA Blind Pointing

- Recent X-Band measurements with the standard, and an enhanced model.
- All the best pointing antennas are numbered less than 14.
- This is not believed to be related to EVLA retrofits.



Referenced Pointing Results

- Normal procedure is to use X-band for referenced pointing.
- Recent data (shown later) demonstrate we are close to the required RSS accuracy.

Misc. Antenna Requirements

- There are requirements listed for the following:
  - Subreflector positions (focus, horizontal positioning, tilt, rotation).
  - Cassegrain Focus Feed Positioning
  - Antenna Slew and Settling Times
- These requirements are similar to those established for the VLA.
- Results:
  - To be determined.
  - No effort has gone into measuring these yet.
  - No evidence of serious shortcomings in these areas.

Antenna Sensitivity

- There are band-dependent requirements for all of the following:
  - Antenna Efficiency, ε
  - Antenna System Temperature, Tsys
  - System Equivalent Flux Density, SEFD (proportional to ε/Tsys).

- Results: We have good numbers for L, C, K, and Q bands. Most are preliminary, and better ones will come this winter.

Results (mid-band)

Band (GHz)	Tsys		Aperture Effic. (%	
	Req'd	Actual	Req'd	Actual
1-2	26	28	.45	.42
2-4	26	TBD	.62	TBD
4-8	26	24	.56	.60
8-12	30	TBD	.56	TBD
12-18	37	TBD	.54	TBD
18-26.5	59	45	.51	.55
26.5-40	53	TBD	.39	TBD
40-50	74 -- 116	60 -- 95	.34	.30

Blue = System tested and in place, or under installation.
Green = Prototypes to be tested in 2007 or 2008. Red = Deferred to end of project

Antenna Illumination

- Primary beam pattern similarity
- Main beam efficiency
- Aperture illumination centering

- Results:
  - No work on these items yet. No obvious evidence for problems.

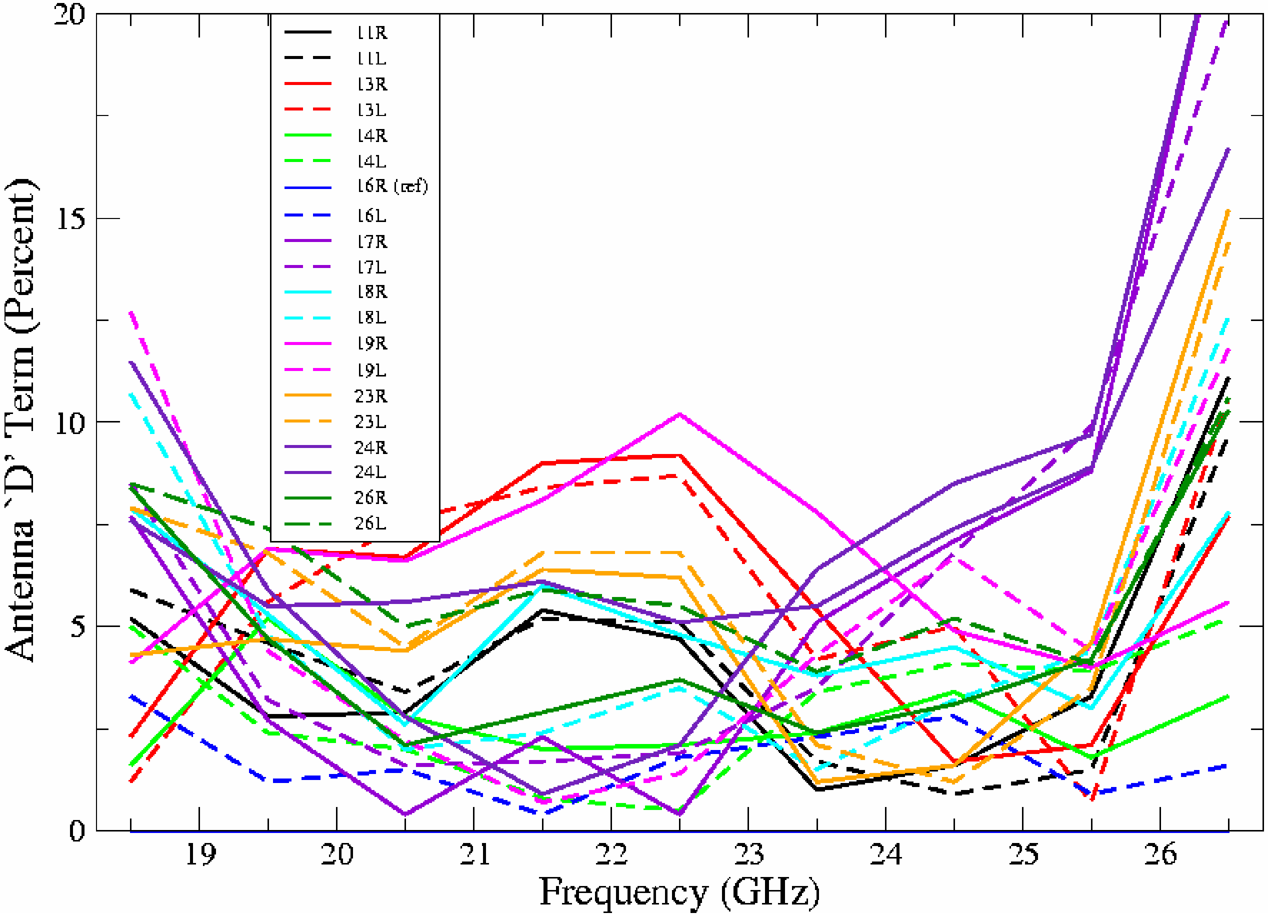
Polarization

- Ellipticity (cross-polarization) limits
  - Less than 5% leakage of total intensity into ‘RL’ and ‘LR’ products.
- Linear polarization (‘D’ term) stability
  - Stable to 0.1% in leakage.
- Beam squint stability
  - Separation of ‘R’ and ‘L’ beams constant to 6”, over 8 hours.

- Results:
  - At K and Q bands, we have the final systems in place, and preliminary measurements are given.
  - At L and C bands, we await the final OMT/polarizers.
  - S, X, Ku, and Ka bands await the prototype systems.

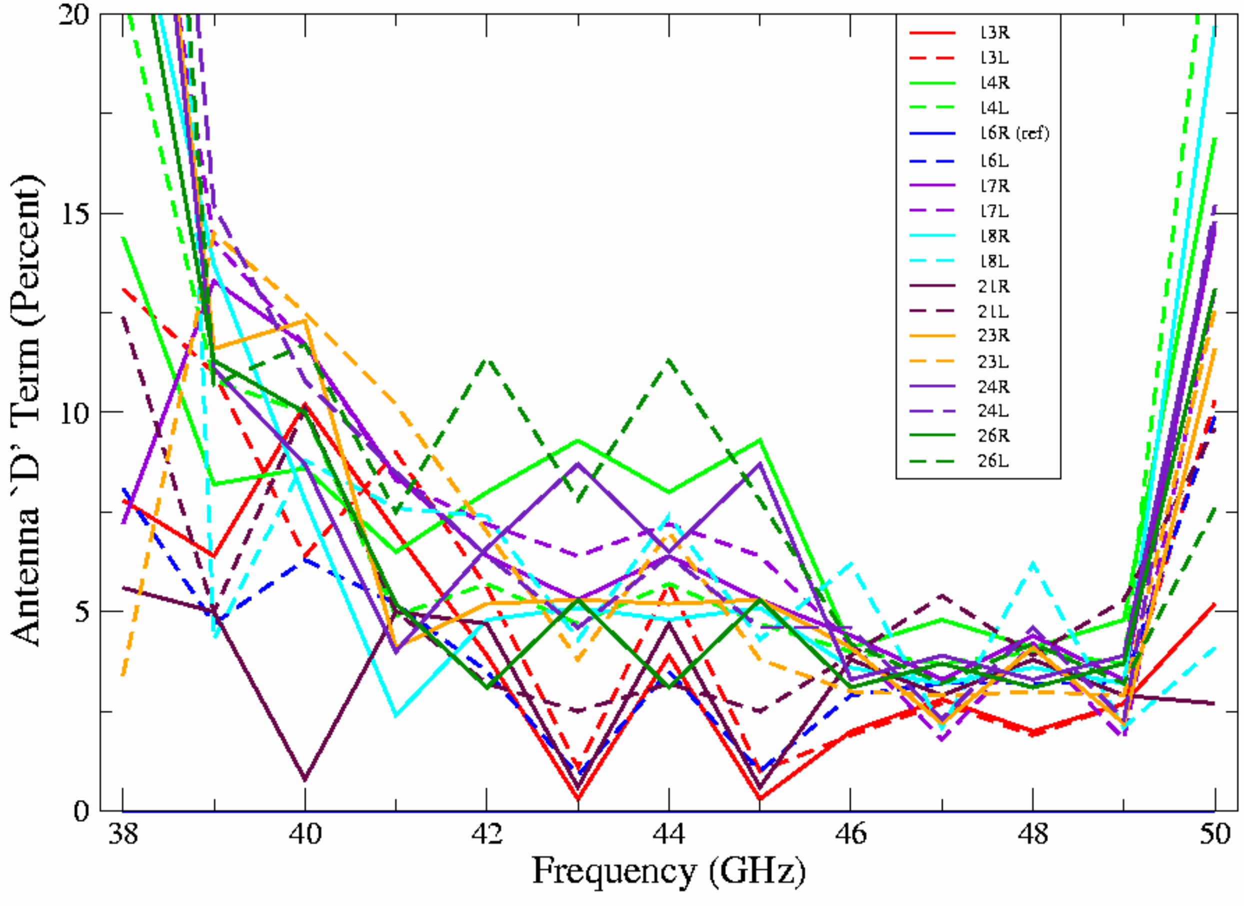
K-Band Cross Polarization

- Shown are the antenna 'D' terms, referenced to 16R.
- Most systems meet the 5% requirement at all frequencies between 19 and 26 GHz.



Q-Band (40 – 50 GHz)

- All antennas meet the requirements between 46 and 49 GHz.
- Performance steadily worsens below 46 GHz.



Polarization Stability

- The cross-polarization stability requirement is much more important than the cross-polarization amplitude.
- We expect good stability, as the polarizers are isolated in a cryogenic environment, and the antennas are stable.
- Observations to determine the stability have not yet begun.

Antenna Gain Determination

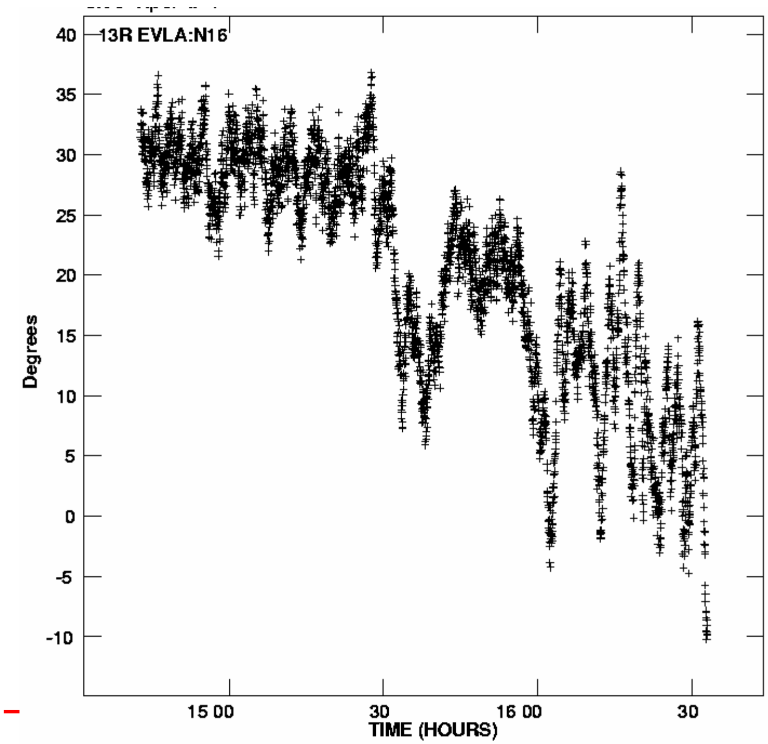
- The overall goal is to be able to determine the source spectral flux density, relative to an established standard, with an accuracy of
  – 0.5% for non-solar observations, and
  – 2% of solar observations.
- This places requirements on:
  – Correlator linearity and performance
  – Accuracy and linearity of system temperature determination
  – Ability to correct for antenna gain dependence on elevation
  – Ability to correct for atmospheric absorption

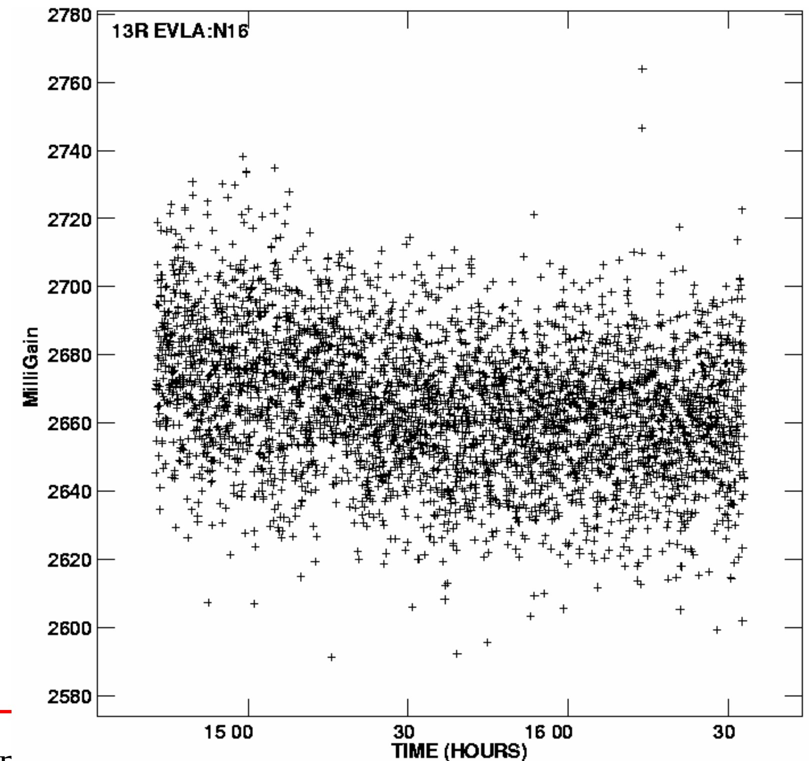
Antenna/Electronics Requirements

- System phase stability
  - A detailed list of requirements on different time and angular scales (all at 50 GHz):
    - 1-second rms phase jitter < 10 degrees.
    - Phase change over 30 minutes < 100 degrees
    - Fluctuations about mean slope of 30 minutes < 30 degrees.
    - Phase change upon source change < 15 degrees.
- Electronics ‘headroom’ requirements
  - To accommodate high external signals, high electronics linearity requirements, or ‘headroom’ have been set.
  - Values from 47 dB (at L-band) to 27 dB (Q-band) between cold-sky power and 1db compression have been established.

Gain Stability

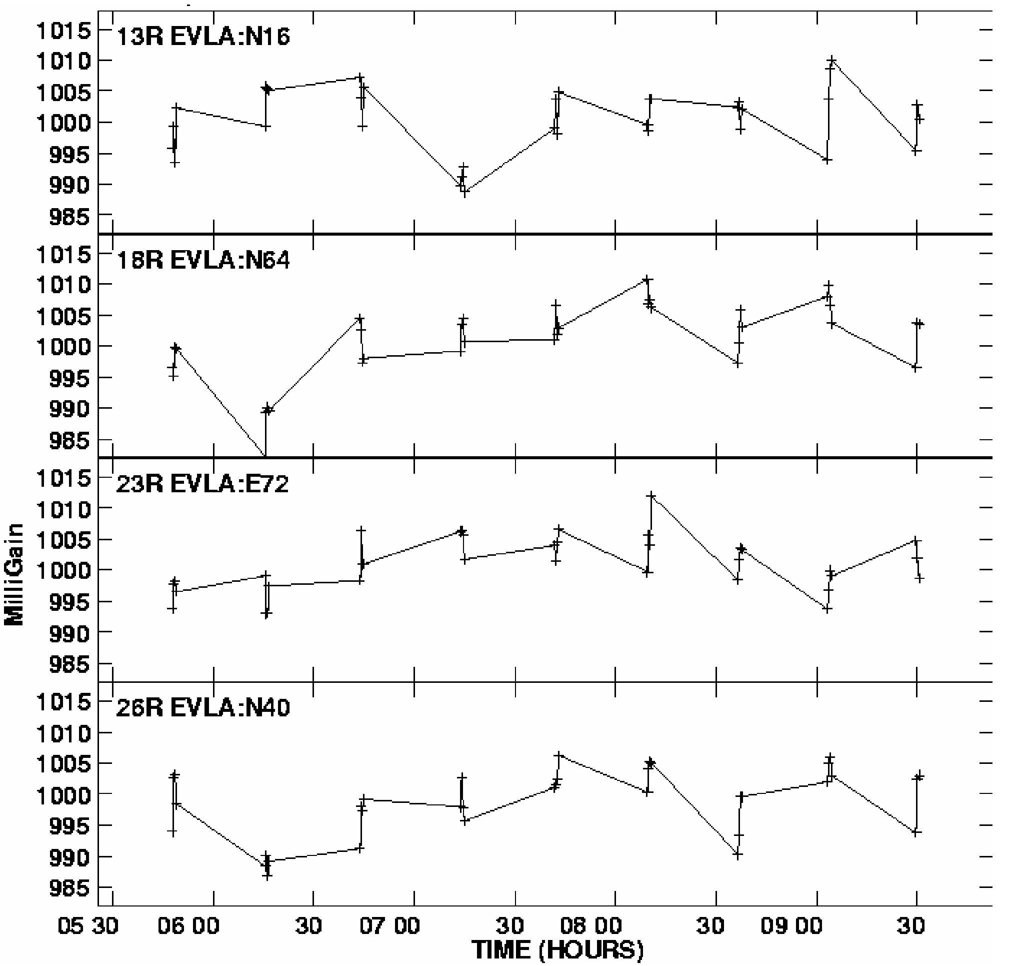
- 6cm observations of 3C84 for two hours in 'A' config.
- Amplitude change (1%) likely due to visibility change.
- Phase behavior consistent with atmospheric perturbations.





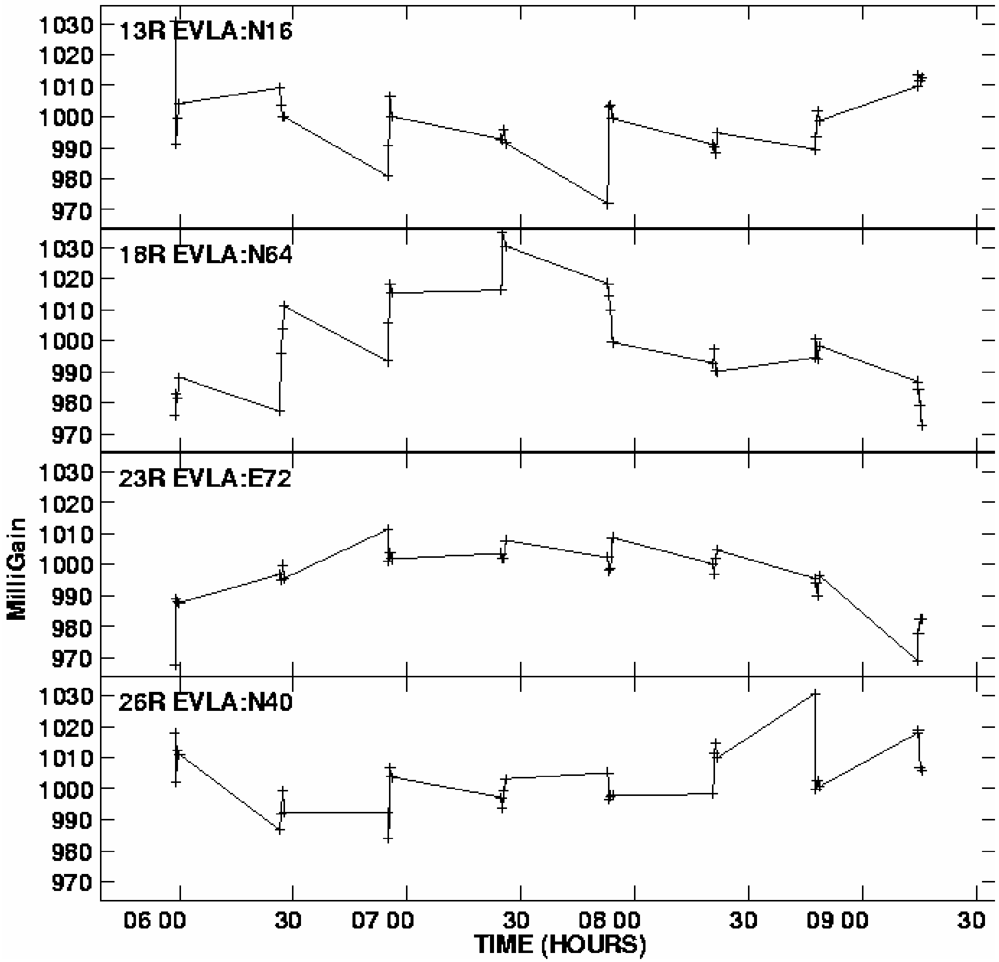
High-Frequency – K-Band

- Two sources, BLLac and 3C454.3, separated by ~1 radian, observed alternately.
- Referenced pointing determined at X-band.
- Elevation-dependent gain determined on one, applied to the other.
- Amplitude deviation of 0.5% corresponds to an offset of 7”.



Stability – Q-Band

- Same experiment, Q-band
- 3.5 arcsecond offset gives a 1% drop in voltage.
- Slow ‘curvature’ in antennas 23 and 18 likely due to incorrect Q-band collimation.



Results

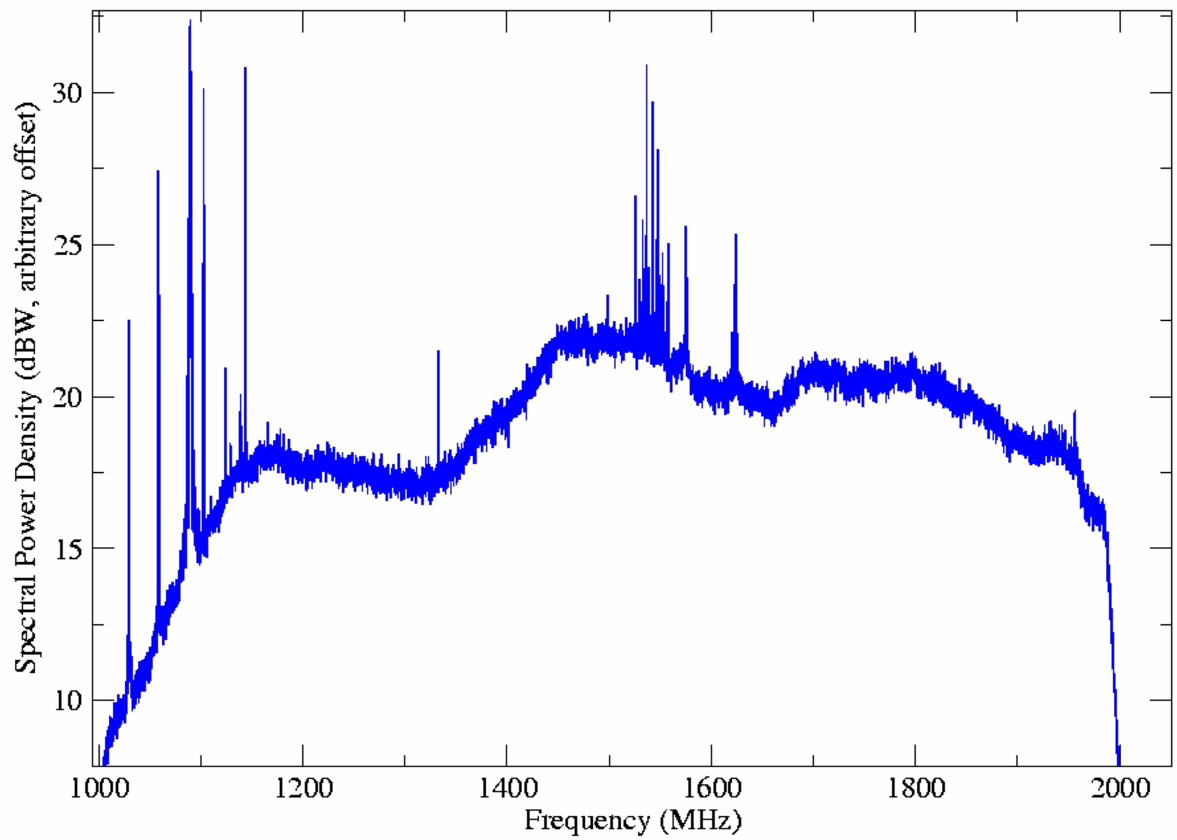
- Amplitude:
  - Close, but not there. Some issues with Tsys correction, probably. Will need to await WIDAR correlator for final resolution.
- Headroom:
  - May not meet at some bands. Our requirements are very stringent, and may be relaxed.
  - Need to monitor system power with full BW, and determine realistic levels for 1 dB compression.
- Phase Stability:
  - Short term (< 1 hour) o.k., long-term not.
  - Long-term phase stability problems have known origin – work to correct is in progress.
  - WIDAR correlator will get rid of 'delay clunks'.

Bandpass Characteristics

- Amplitude Stability (frequency/time)
  - Amplitude bandpass stable to 0.01%, over 1 hour, over bandwidth of 0.1% of frequency.
- Phase (frequency/time)
  - Variations less than 6 millidegrees.
- Gain (power) slope and ripple limitations
  - Spectral power density slope to 3-bit digitizer < 3 dB over 2 GHz.
  - Fluctuations about this slope < 4 dB
- Differential Phase within Bandpass
  - 2 degrees over 1 MHz at, Ku, K, Ka and Q bands.
- Residual Delay
  - 2.8 nsec maximum residual delay.

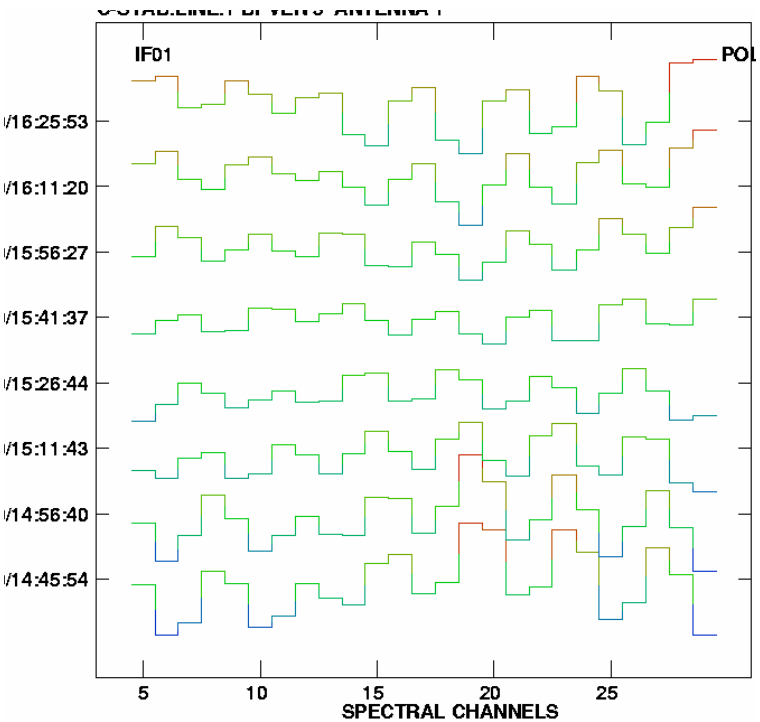
L-Band Bandpass – 14A

- L-Band Bandpass has significant roll-off below 1.15 GHz.
- Witn 8-bit digitizer, this is o.k., provided more than 3 bits used for the noise.

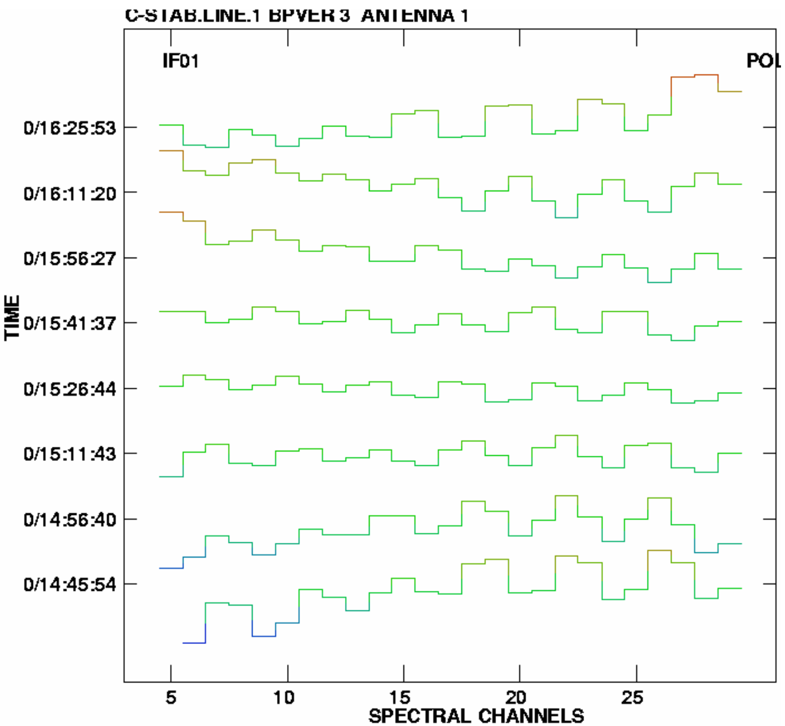


VLA Antenna Stability
15 minute differentials

- One of the better VLA antennas, showing the ~3 MHz ripple.
- At 5 GHz, relevant frequency span is 5 MHz.



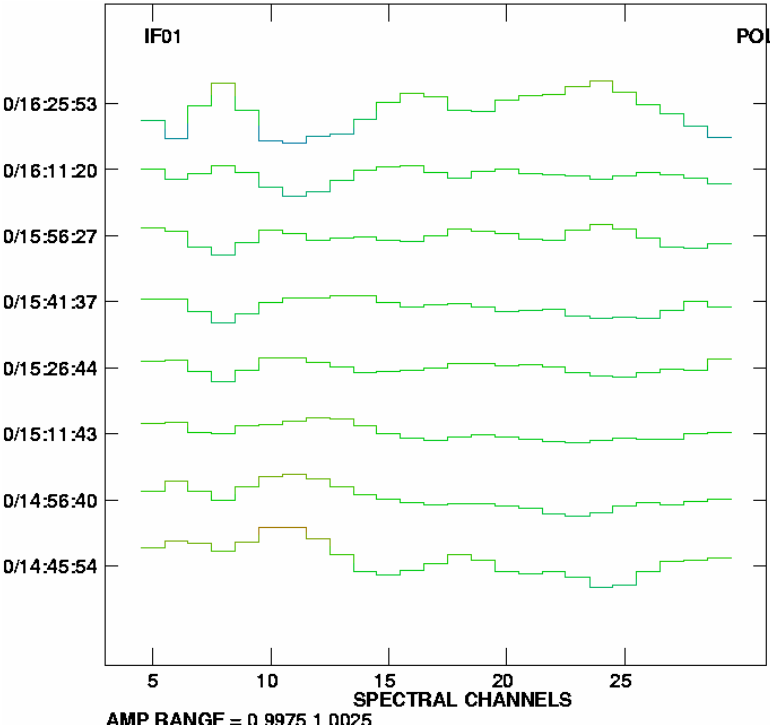
Amplitude: +/- 0.25%

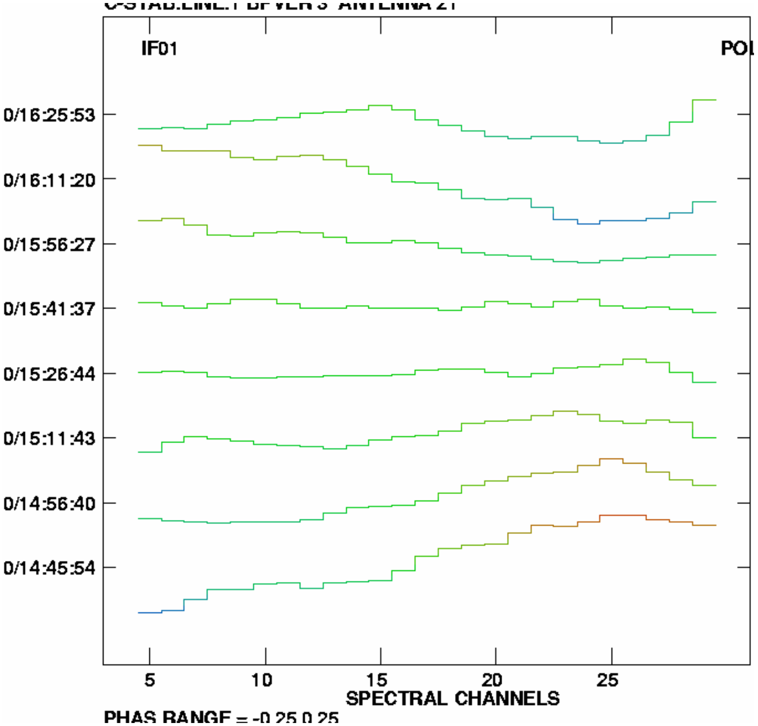


Phase: =/- 0.25 deg

EVLA Antenna #21

- The ripple is gone.
- Broader structure likely due to VLA back-end filters and electronics.





Amplitude: +/- 0.25%

Phase: +/- 0.25 deg

Bandpass Observations

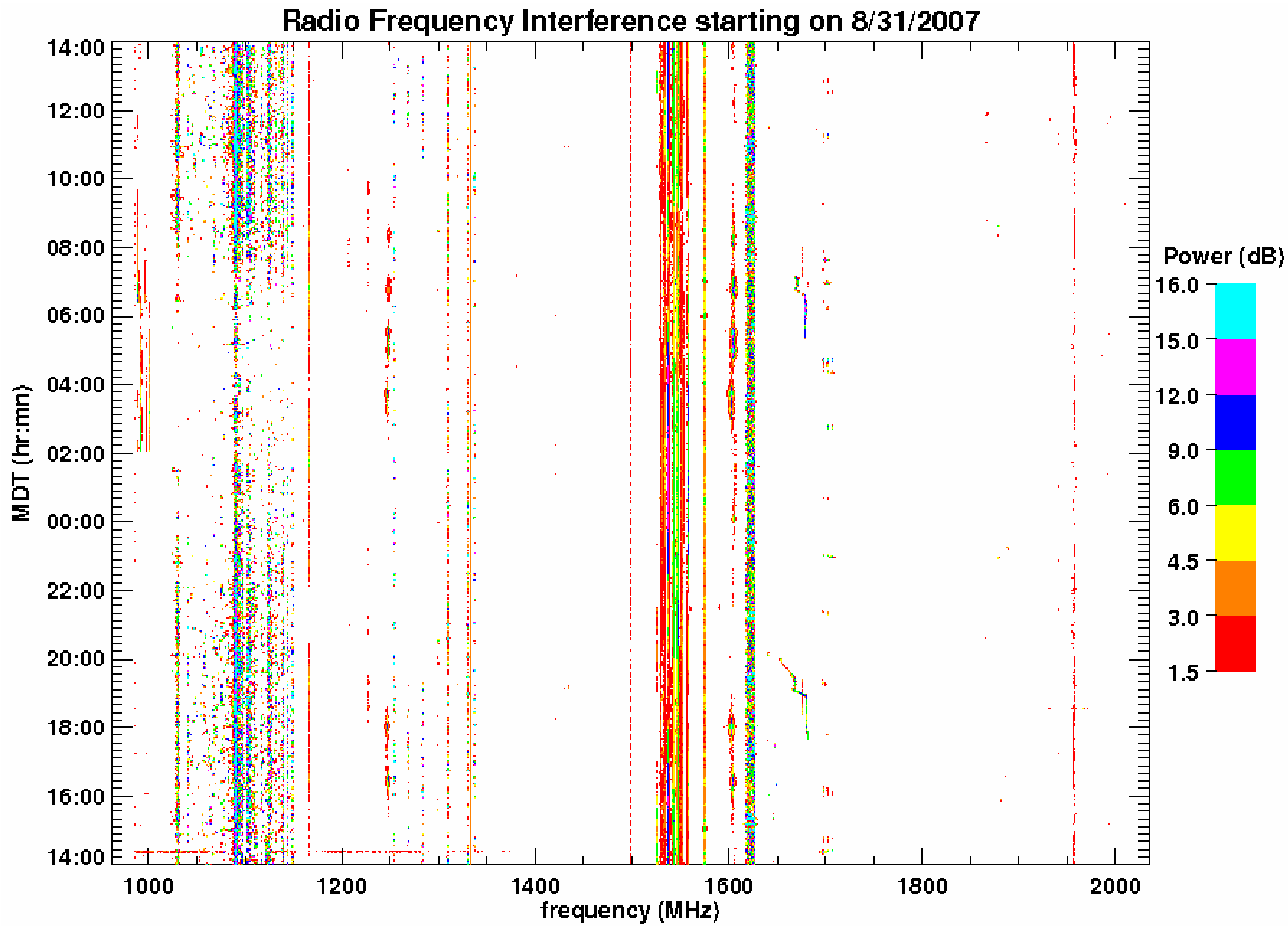
- Amplitude stability much better, but short of requirements by factor of a few.
  - Waveguide ~6 MHz ripple is gone.
  - Residual broad-band changes remain.
  - Further determinations await WIDAR correlator.
- Phase stability also well short of requirements.
  - VLA delay stepping introduces a oscillating phase slopes and offsets – makes careful measurements difficult.
  - WIDAR correlator needed for better determinations.
- Wideband (2 GHz) SPD slopes to be offset with Gain Equalizer.

Summary

- Most of the work required for identification and correction of major system performance problems is now done.
  - No new amplitude/phase phenomena have been discovered for many months.
- We believe that most (if not all) major antenna and array performance requirements will be met.
- Some requirements may be relaxed, upon review of impact and system performance.
- An organized scientific ‘check-out’ procedure for full system performance for all antennas awaits completion.

24-hour L-Band Spectrum

- L-Band Spectrum, taken with 250 kHz resolution.
- Used antenna 14, with prototype OMT.



Zoom-In to DME Area

- 1025 to 1150 MHz contains the DME signals.
- Each pulse only 2 microsec long, at 30 repetitions/sec.
- Signals at 1030 are Gnd -> Air Transponder from ABQ airport.
- Signals at 1090 are aircraft response.