EVLA Technical Performance

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With much essential help from Barry Clark, Ken Sowinski, Vivek Dhawan, Walter Brisken, George Moellenbrock, Bob Hayward, Dan Mertely, and many others.

Performance Requirements

- Chapter 2 of the Project Book gives the antenna and array performance requirements.
- Ultimately, all EVLA antennas must perform at these levels.
- Our efforts in the past 18 months have been focused on:
  - Establishing basic performance of the EVLA antennas 13, 14, and 16.
  - Identifying and debugging a wide range of interesting (!) problems…
  - Developing methodologies for efficient and effective performance checkout procedures

EVLA Testing Team

- The (unofficial) testing team:
  - Ken Sowinski, Rick Perley, Barry Clark, Vivek Dhawan, Walter Brisken, George Moellenbrock, Mark Claussen.
  - In addition, Chris Carilli, Claire Chandler and Michael Rupen have included EVLA antennas into their science runs.
- A very intensive process – tests done daily, results back to engineers/programmers within hours.
- An amazing range of problems uncovered and repaired.
  - Two major areas: Performance and Reliability.
- We believe we are 'over the hump' in tracking down reliability and performance issues.
- Undoubtedly some remaining subtle problems.

Antenna-Pointing

- EVLA requirements for pointing:
  - 6” blind, 2 – 3” referenced (RSS).
  - Based on performance of best VLA antennas.
- EVLA antenna pointing problems now rectified, referenced pointing now enabled.
- Based on the four EVLA antennas, we are quite confident the requirements will be met via implementation of an improved model.
- `Super-Sidereal Tracking’ mode not implemented. Awaits identification of necessary funding.

Antenna-Efficiency

- Table shows requirements and status.
- Observations made on known standards calibrated with hot/cold loads.
- We are on track to meet all requirements.

Band	Req.	Obs.
L	.45	.43 - .50
S	.62	TBD
C	.60	.55 - .65
X	.56	TBD
U	.54	TBD
K	.51	.48 - .56
A	.39	TBD
Q	.34	.26 - .29*

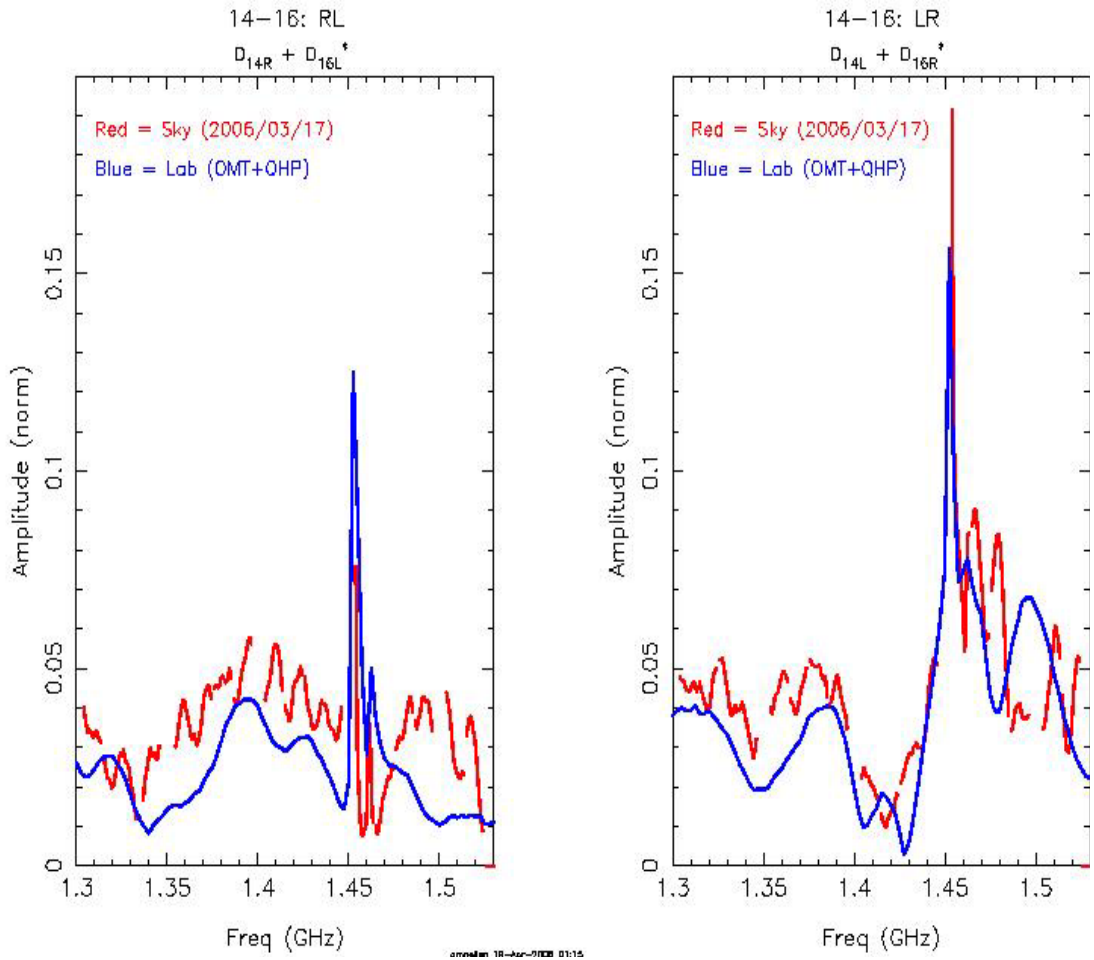
* Observations made without optimal focus or subreflector position. Further holography required.

Antenna Polarization

- **Linear:** Requirements set to give < 5% cross-polarization response, stable to < 1% over 12 hours.
  - **C-Band:** Easily meets specs at 4850 MHz, but we are using VLBA-style polarizer. We await the new OMT/Hybrid combination.
  - **L-Band:** Have new hybrid, but with old VLA OMT. Results are encouraging (following slides).
  - **K, Q Bands:** EVLA polarizers in place. No problems found, and none are expected.
- **Circular:** Set by beam squint – no change from VLA expected. Measurements to follow.

L-Band Polarization
(George Moellenbrock)

- Recent sky tests (Red) show acceptable cross polarization.
- Spike at 1450 MHz due to trapped modes in VLA OMT
- Blue lines show predicted polarization from lab measurements.



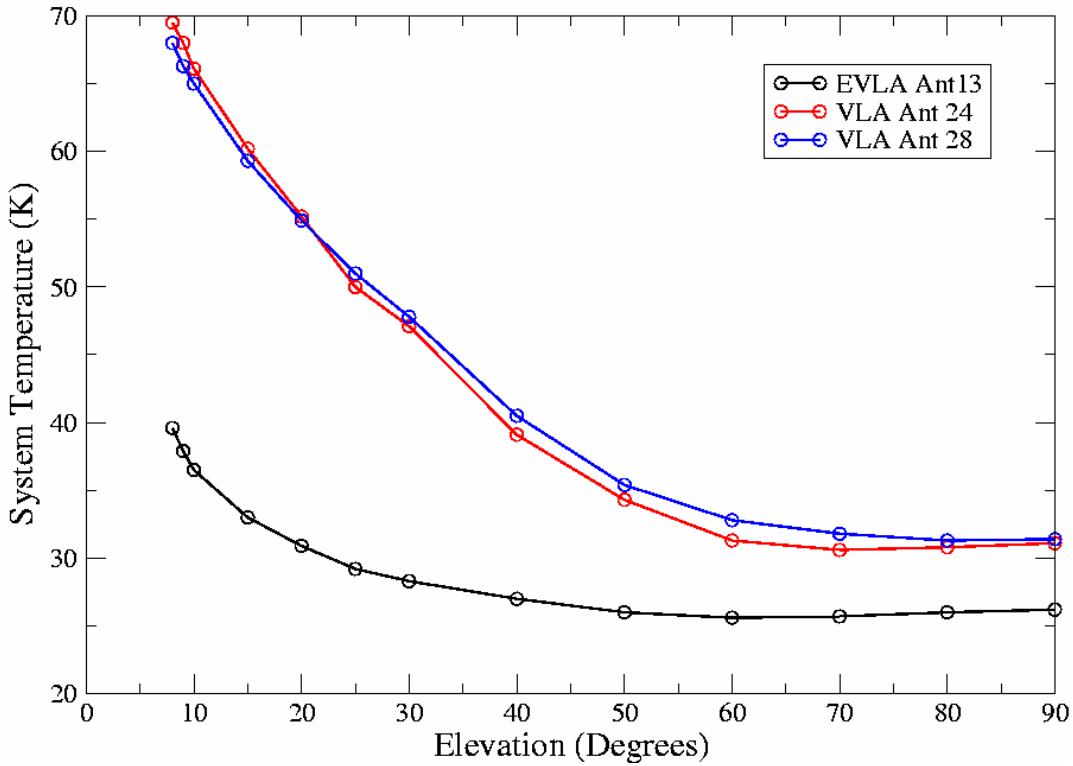
Receiver Tsys

- System Temperature: Results in Table.
- All measurements made with hot/cold load calibration, at output of FE or IF on the antenna.
- Requirements are met, especially at high frequencies.

Band	Req.	Obs.
L	27	28
S	27	TBD
C	27	24
X	31	TBD
U	38	TBD
K	61	45
A	55	TBD
Q	70	65

Tsys vs. Elevation L-Band

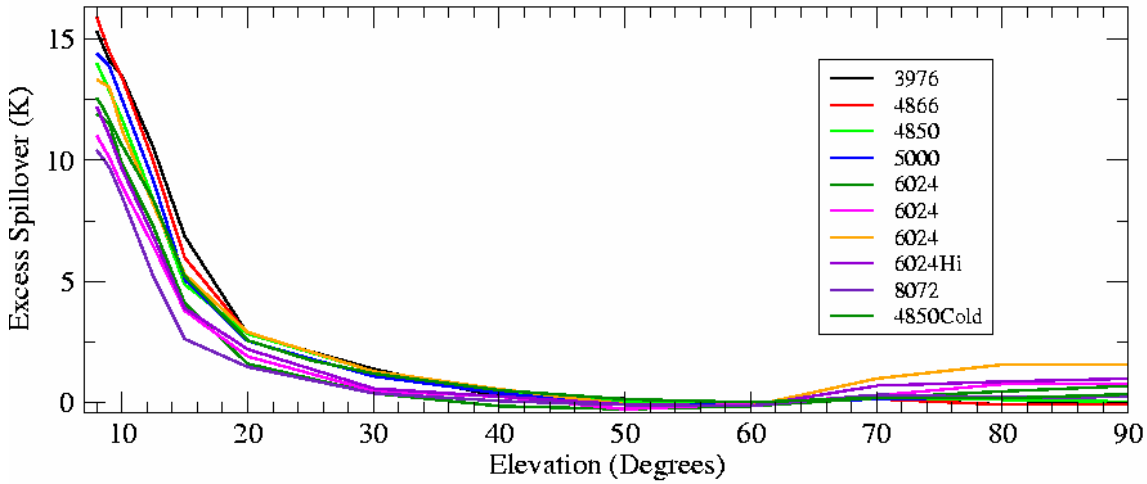
- A major problem with VLA L-band is strong elevation dependence on Tsys.
- EVLA feed has much better elevation performance.
- This improvement will mostly offset the reduced efficiency of EVLA feed.

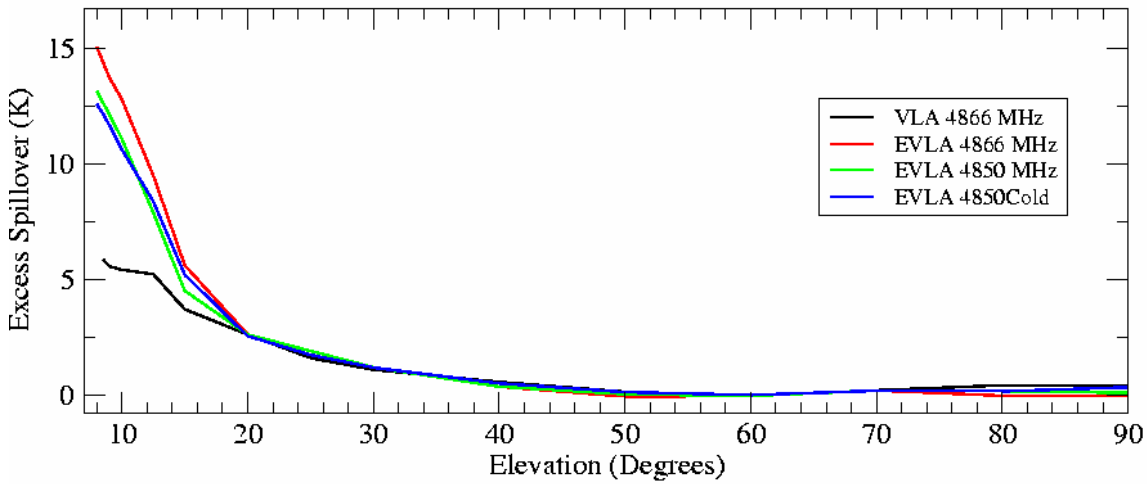


Variation with Elevation C-Band

- At C-band, the feed shows excellent performance from 4 to 8 GHz.

- Some excess spillover at very low elevations

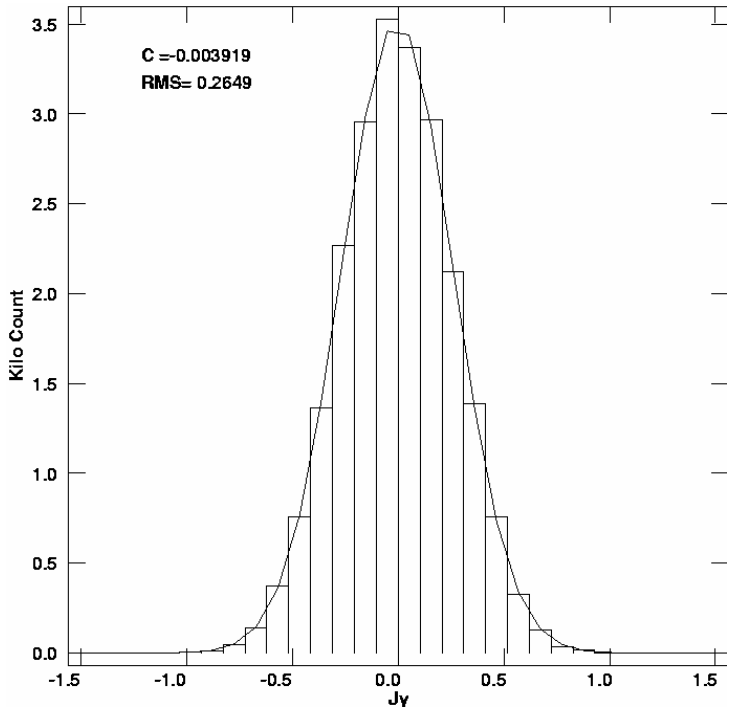


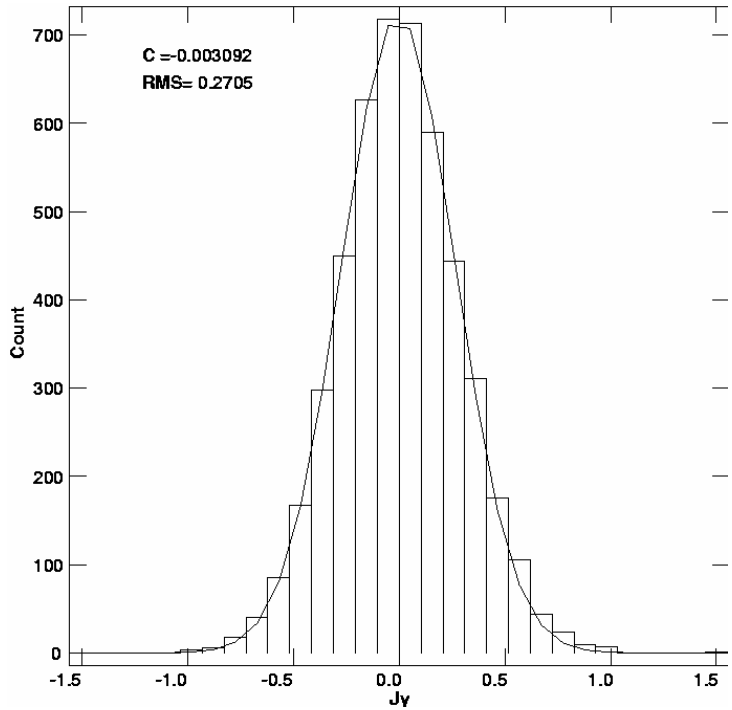


Interferometer Sensitivity

- Although antenna performance is at or better than requirements, the ‘bottom line’ is the sensitivity of the interferometer.
- Initial interferometer observations revealed numerous problems, traced to aliased responses. We believe all are now rectified.
- Some sensitivity issues remain, especially at L-band. These are being investigated now.

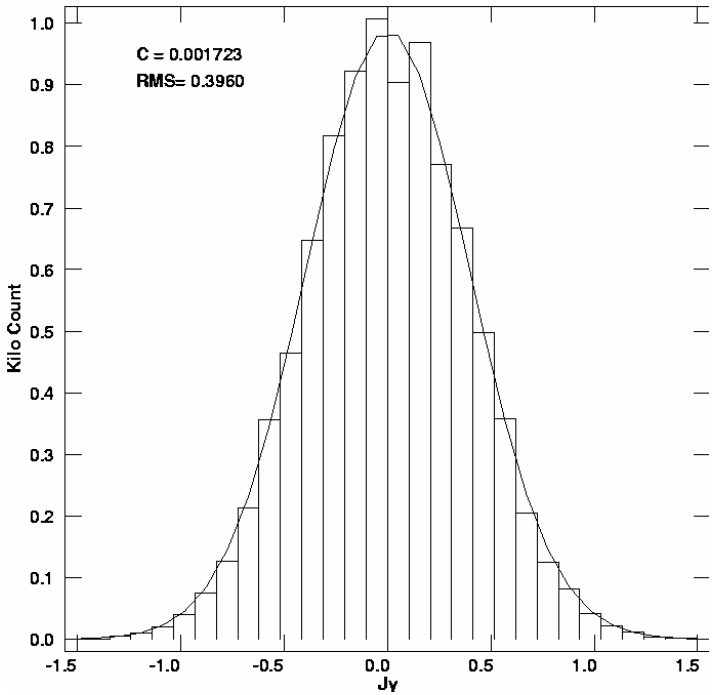
X-Band Interferometer Sensitivity

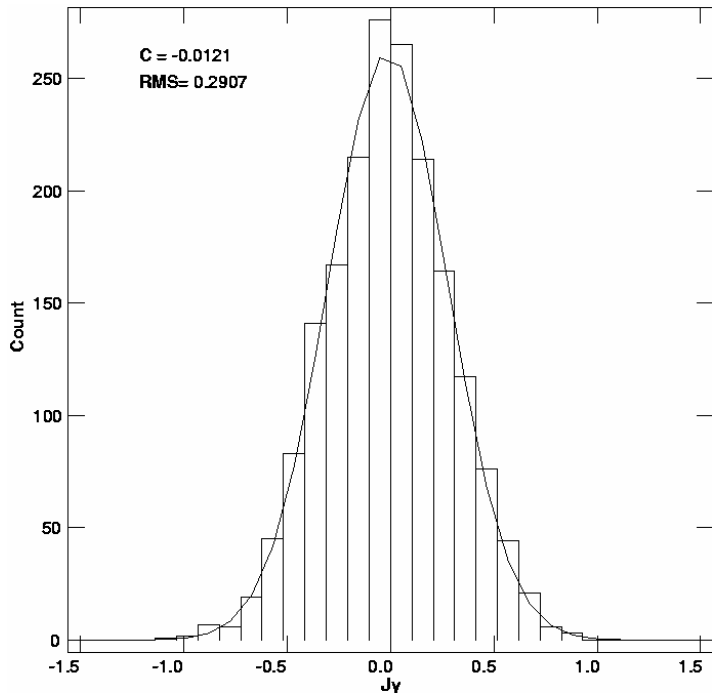




- Left: VLA typical noise histogram
- Right: EVLA antennas 13, 14, 16, 18
- EVLA antennas same as VLA – as expected.

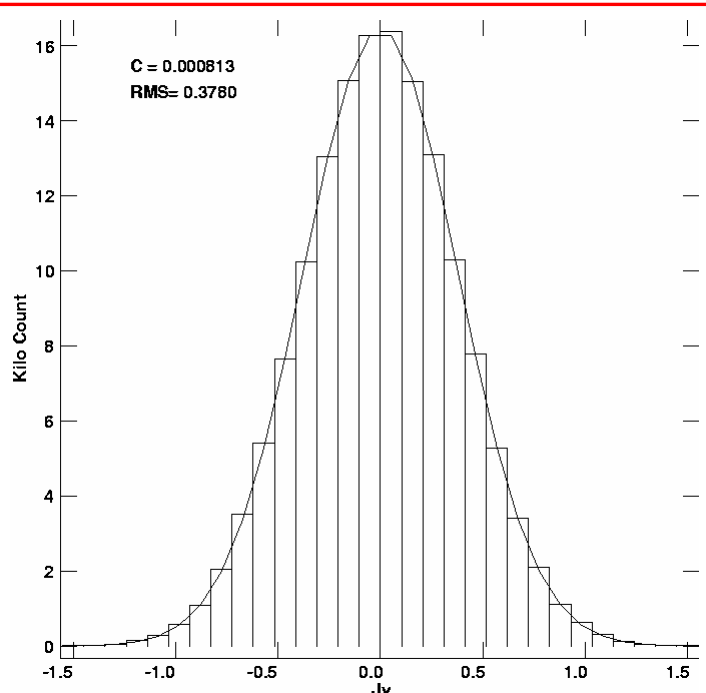
C-Band Interferometer Sensitivity

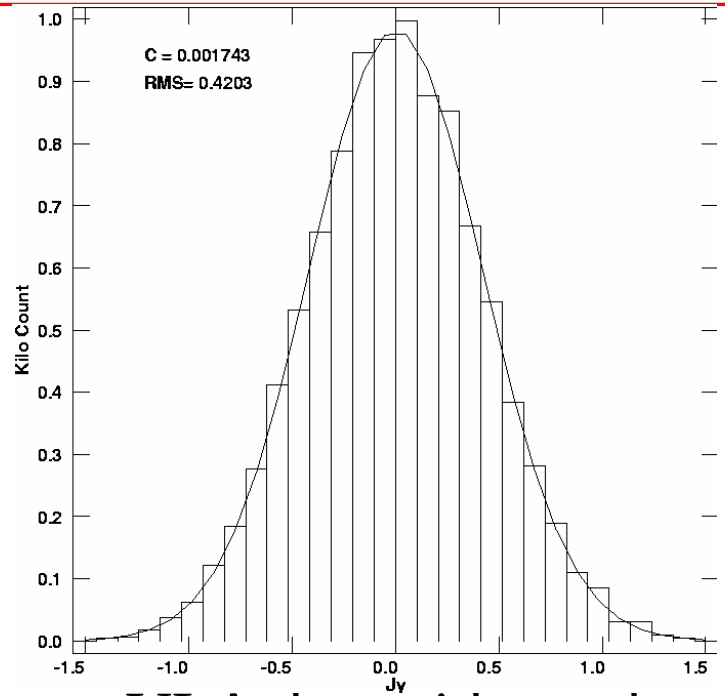




- Left: VLA average
- Right: EVLA antennas 13, 14, 16.
- EVLA antennas notably better than average VLA antennas.

L-Band Interferometer Sensitivity





- We expect performance similar to VLA, but with much less elevation dependence.
- Left: median VLA, Right: EVLA, at 1385 MHz, El = 80.
- 10% worse than VLA average at zenith.

High Frequency Sensitivity

- Accurate measures of K and Q band sensitivity require optimum conditions:
  - Clear skies
  - Low winds
  - Dry atmosphere
  - Referenced pointing
  - Short baselines (preferred).
- We have yet to obtain all of these at one time on any given test.
- We will likely have to wait until the fall for an accurate test.

Gain Linearity/Stability

- No specific requirement on temporal gain stability.
- Tsys monitoring requirement of 0.5% accuracy.
  - Needed to compute visibility amplitude from correlation coefficient.
- Calibrator observations show (short-term) amplitude stability as good as VLA – this meets the 0.5% requirement.
- Some issues of Tsys monitoring stability remain. Occasional unexplained deviations observed, cause as yet unknown.
- Long-term amplitude stability appears to be good, but more data are required for definitive estimate.

Phase Stability

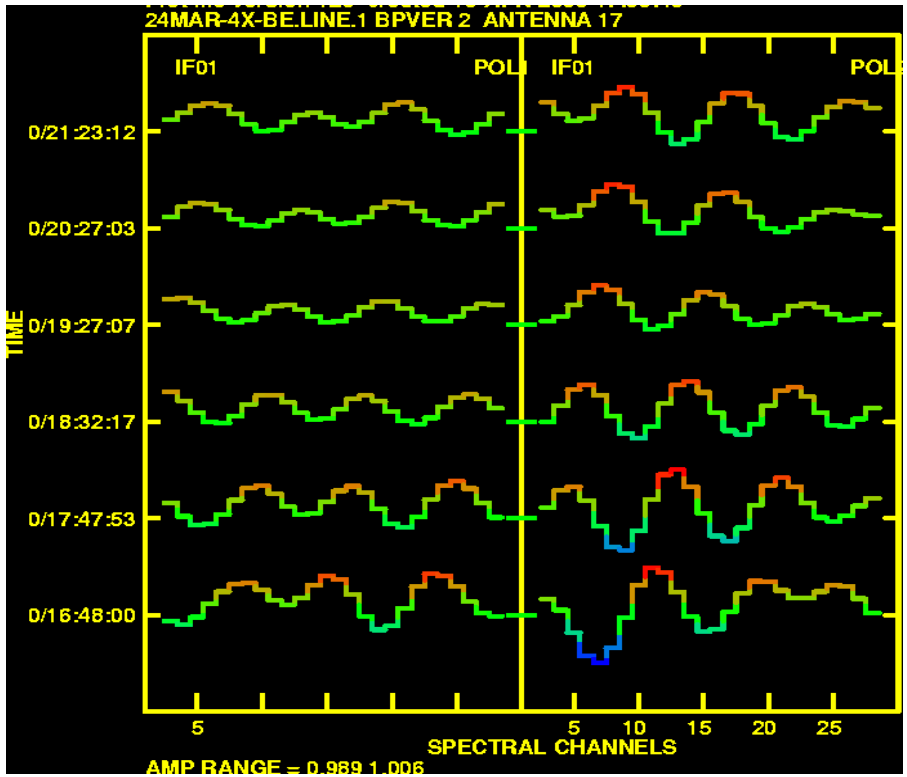
- Observed (short-term) phase as good as VLA antennas.
- Long-term phase stability check requires round-trip phase correction, and implementation of VLA weather.
- Neither is yet employed.
- R-T phase correction system better than VLA's.
- Detailed tests ongoing, and results are encouraging. (Vivek Dhawan leads this effort).

Bandpass Stability

- A very difficult spec has been set: 0.01% amplitude, and 0.007 deg phase stability, on
  - Timescales less than 1 hour, and
  - Frequency scales less than 0.1% of observing frequency.
- Recent observations of 3C84 at X-band show we're close – and probably limited by VLA base-band hardware.

VLA Bandpass Amplitude
Differential Hourly Snapshots

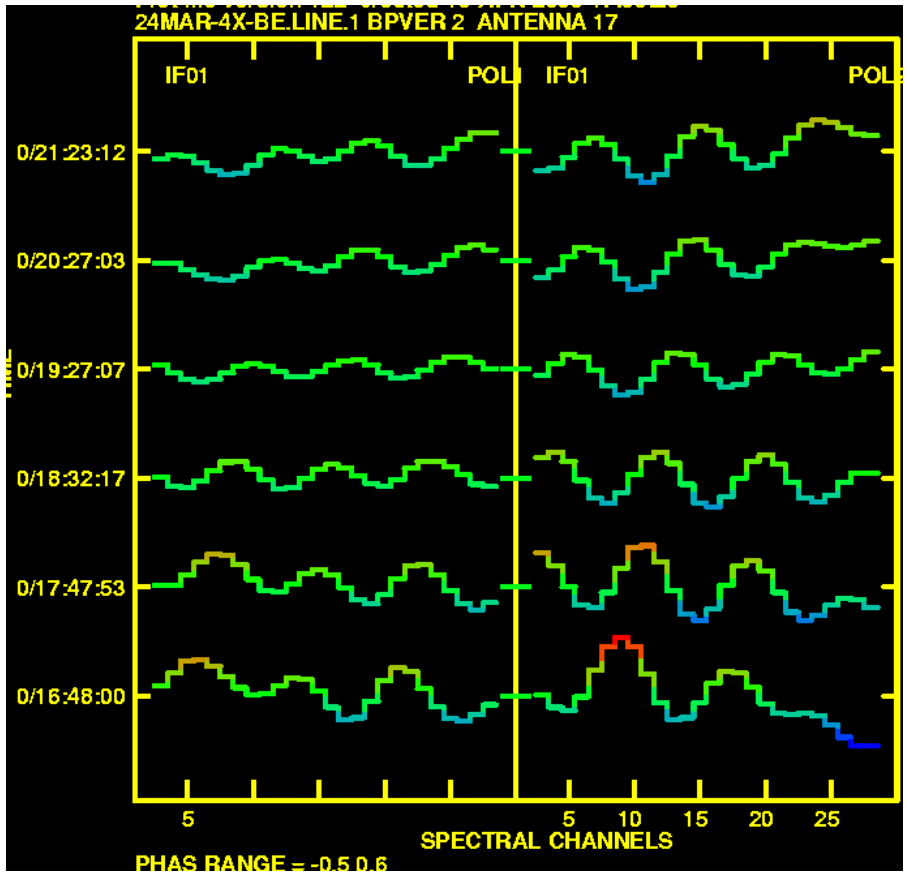
- VLA antenna 17 amplitude, X-Band
- 4 MHz Ripple due to waveguide reflections.
- Magnitude ~ 0.5%
- Typical for all VLA antennas.



RCP LCP

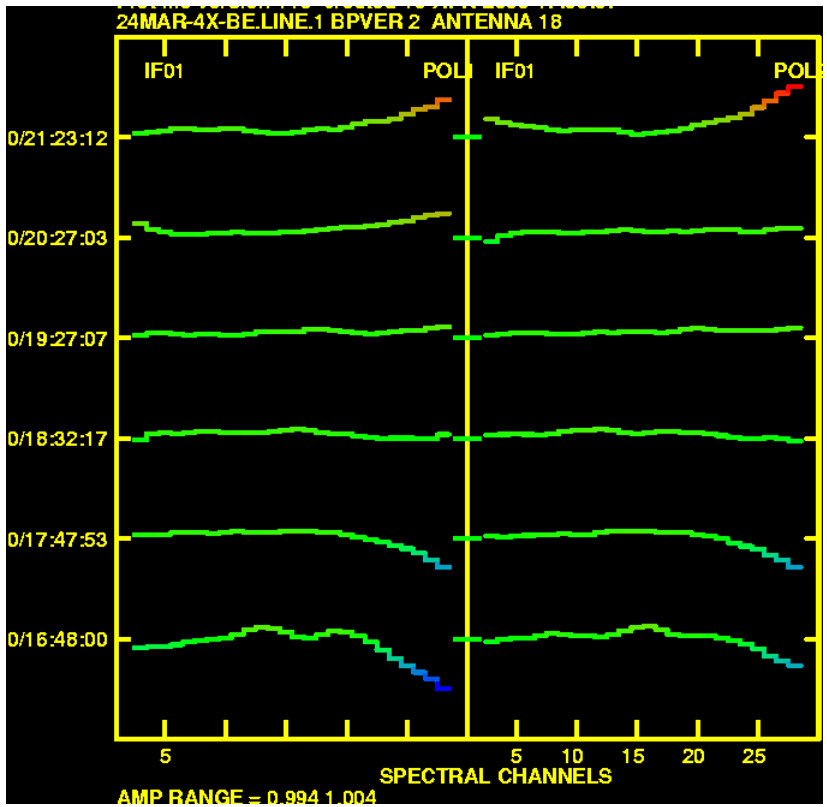
VLA Phase

- Showing VLA ripple in phase.
- Magnitude ~ 0.5 degrees.



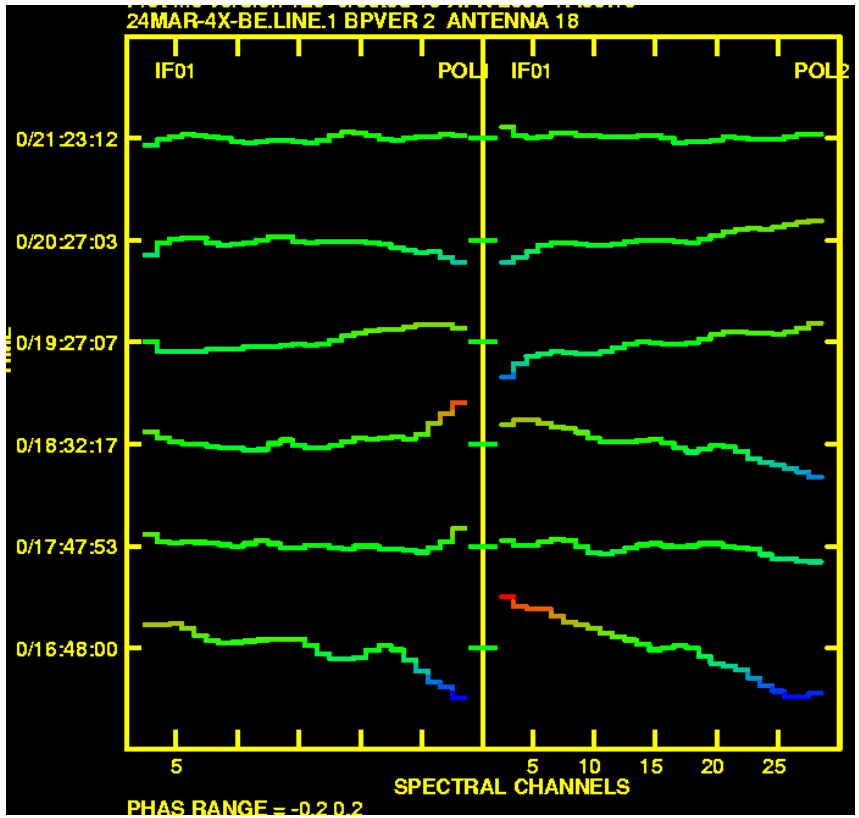
EVLA Antenna 18 Amplitude Results

- Amplitude stability excellent.
- No sign of VLA's 3 MHz ripple.
- Full range is 0.4%.
- Away from baseband edge, range is ~.05%.
- Variation likely due to VLA baseband filter.



EVLA Antenna 18 Phase

- Hourly observations of bandpass at X-band.
- Mean bandpass removed.
- BW is ~10 MHz
- Phase peak range 0.2 degrees.
- Away from baseband edge, phase range is 0.04 degrees.
- Instability origin unclear, but unlikely to be FE.



RCP LCP

Other Requirements

- Other PB requirements (passband gain slope, ripple, antenna primary beam, etc.) remain to be measured.
- Procedures to do these are well known, and will be implemented this year.
- Overall – we are satisfied with performance, but there is much yet to be done.
- We expect to meet all hardware performance requirements!

EVLA Antenna Checkout

- We have not yet implemented a standard EVLA antenna performance checkout procedure.
  - Focus has been on establishing basic performance, and chasing down a wide range of problems.
- A checkout plan has been developed by Claire Chandler, Chris Carilli and me
- Methodologies are well understood – we have very experienced people in place!
- The plan is to begin this procedure this fall.
- We would like to assign this task to a new person – not yet identified. A post-doc would be ideal.