EVLA Hardware Testing

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With much essential help from Barry Clark, Ken Sowinski, Bob Hayward, Dan Mertely, and many others.

Overview

- I will discuss two types of ongoing tests:
  – Total power measurements of key antenna parameters (i.e. efficiency, spillover, Tsys)
  – Interferometer measurements of key visibility parameters (i.e. amplitude and phase stability, bandpass function, antenna pointing).
- First set of tests done by me and Bob Hayward. Second set by Barry Clark and Ken Sowinski.

EVLA Feeds

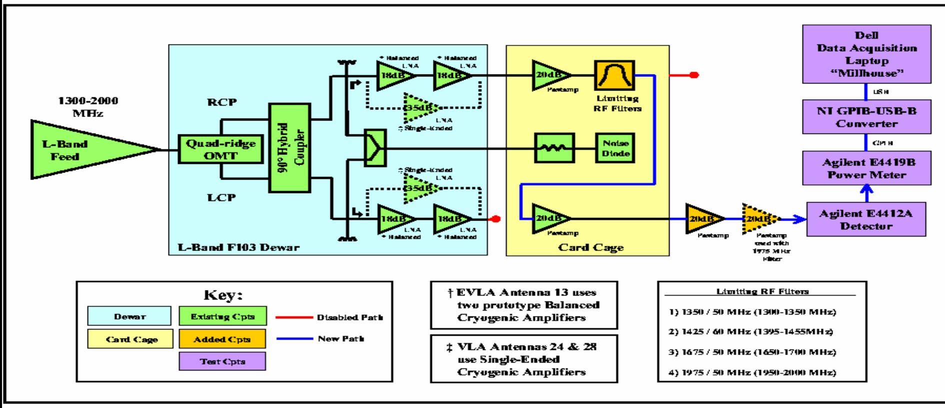
- Before the Project can issue large purchase orders for the production feeds, we must test the prototype feeds in the field.
- There are currently two prototypes to test and evaluate:
  - C-Band (4 – 8 GHz) and L-Band (1.2 – 2 GHz).
- Parameters we need to know, as a function of frequency, are:
  - Gain (efficiency)
  - Tsys
  - Spillover (especially as a function of elevation)
  - Focus
  - Beam power pattern (main beam and sidelobes)

Methodology/Calibration

- Efficiency tests require a total power system.
- Best done at the RF, in the antenna.
  - Requires suite of RF filters (not generally available)
  - Backend tests would include other efficiency losses.
  - TP at IF, in antenna quite desirable – tuning flexibility
- L-Band tests: RF only (no IF available)
- C-Band tests: RF and IF (allowed easier change of frequency).
- Calibration done by hot load (absorber over the horn) and cold load (on sky).

Measurement Setup

System set up by Bob Hayward and Dan Mertely



Methodology

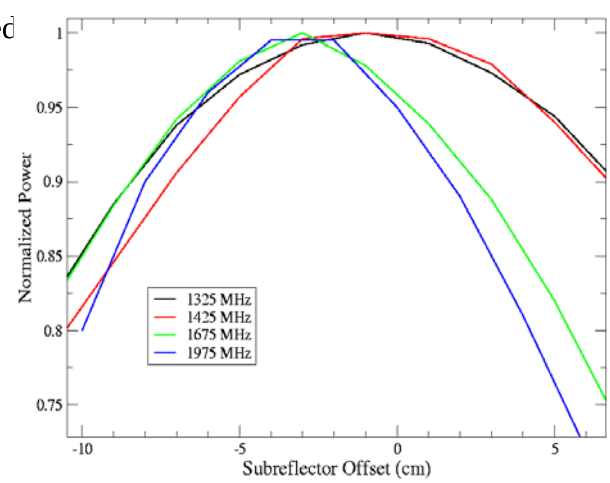
- Efficiency
  – Measure Tsys on and off Cygnus A
- System Temperature
  – Measured at zenith (galactic plane down)
- Focus function
  – Track Cyg A, change subreflector position manually.
- Spillover variation
  – Sky dips from zenith to elevation of 8 degrees.

L-Band Results

- Measurements done at 1325, 1425, 1675 and 1975 MHz.
  - Selection limited by choice of RF filters.
  - Frequency below 1200 MHz not possible at this time.
- Data taken from mid August to late September.
- Data taken on two VLA antennas (24 and 28) for comparison.
  - These were chosen as they have the same hybrid polarizer as the EVLA test antenna.

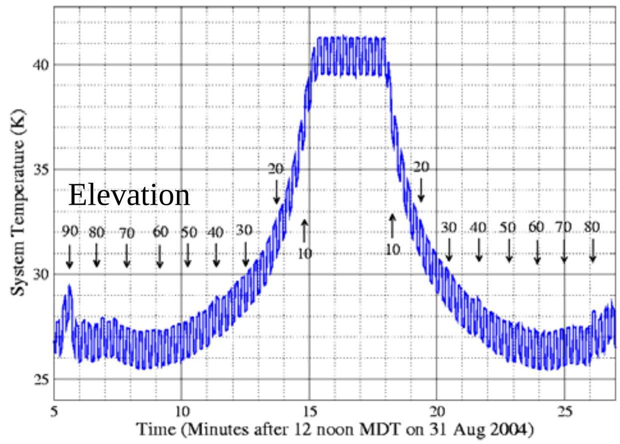
L-Band Gain vs. Subreflector Position

- Shows the expected ~2 cm variation with frequency.
- Feed focus drops ~100 cm between 1.2 and 2 GHz.
- Gain loss at opposite ends of band is less than 1%, in continuum mode with optimum setting.



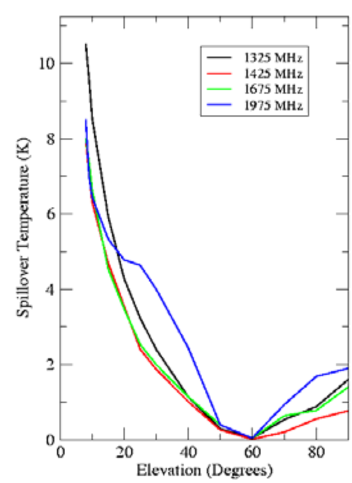
Spillover

- Example of a sky dip for Antenna 13 at 1425 MHz.
- Oscillating power is noise diode, to monitor gain.
- Increase in Tsys quite modest.



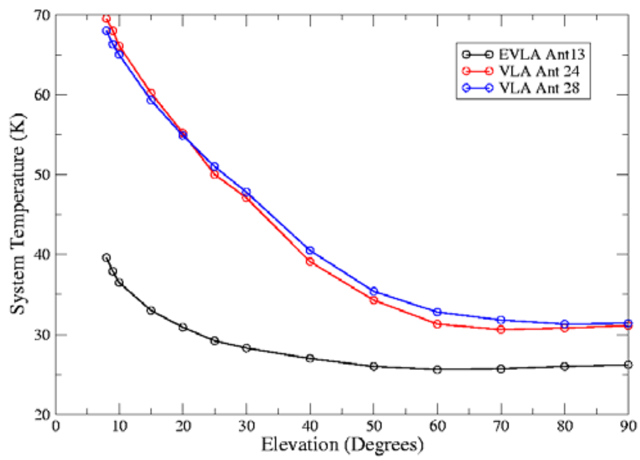
L-Band Spillover Results

- Shows the excess system temperature as a function of frequency and elevation.
- Atmospheric component of 1.0*sec(Z) removed.
- Offset due to T_{rcvr} and vertical spillover (~10K) removed.
- Increase in spillover begins at 40 degrees elevation, rises to ~9K at elevation = 8 degrees.
- This is very much less than the VLA spillover function.



L-Band Results: EVLA vs. VLA

- The EVLA spillover is *much less* than the VLA.
- EVLA Tsys (at Z = 0) about 5K less than VLA.
- Improvement from removal of lens and dielectric polarizer.



L-Band Efficiency

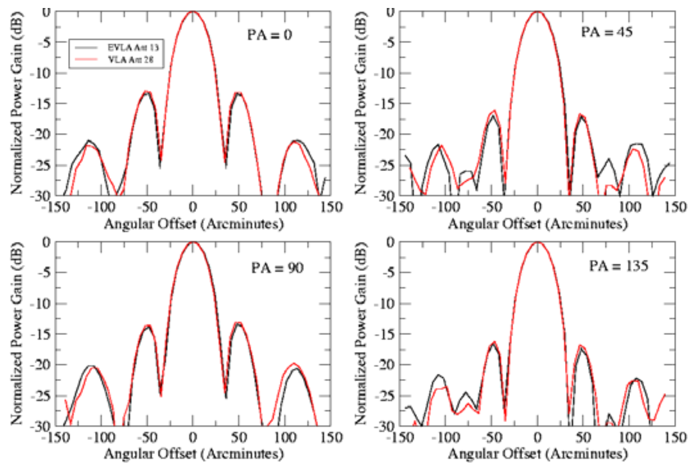
- Cyg A on-offs give the following table.

Frequency	Flux	T_a	ε
MHz	Jy	K	
1325	1680	135	0.45
1425	1558	121	0.43
1675	1315	102	0.44
1975	1101	105	0.54

- The efficiency is ~5% less than predictions from numerical calculations.

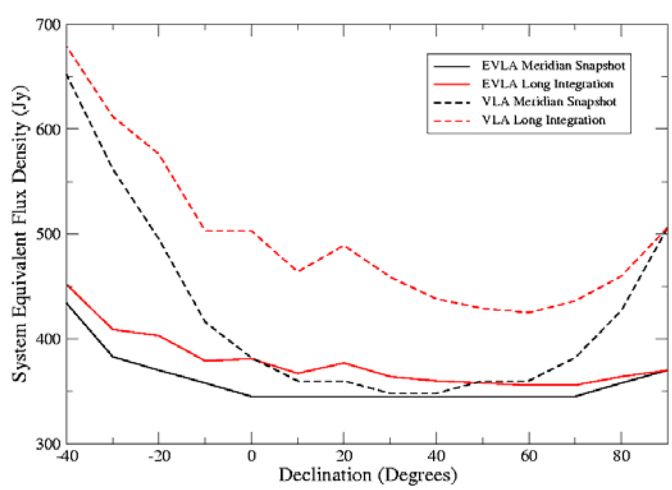
EVLA Beam

- Showing the VLA and EVLA beams at 1425 MHz.
- FWHM are not measureably different.
- EVLA sidelobes slightly less.



L-Band Sensitivity

- The improved elevation spillover has a big effect on integrated sensitivity.
- The SEFD parameter is a useful metric of (G/T).



L-Band Feed Summary

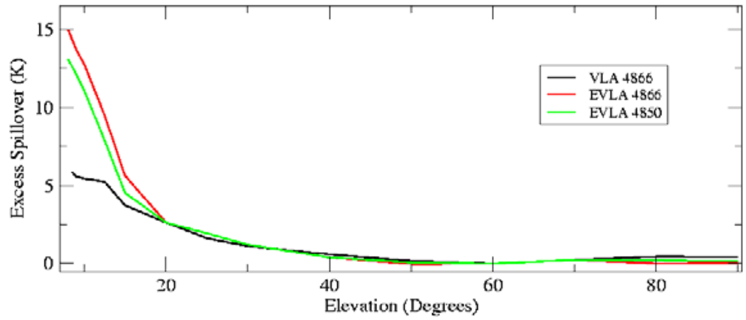
- Although the L-Band feed is not quite as efficient as we had hoped, its superior bandwidth, spillover performance, and lower system temperature combine to make it an acceptable feed for the EVLA.
- We have thus initiated the process to procure these feeds for the project.

C-Band Results

- The methodology was the same, except:
  - The IF system was available, so changing frequency was easy (commandable from the antenna).
  - Pointing errors, and resolution of Cyg A, were problems. Results therefore more uncertain, especially at high end of the band.
  - Could not use a weaker (unresolved) object, as a ~1% gain variation (on 2-minute timescale) is present – origin still uncertain.

C-Band Spillover

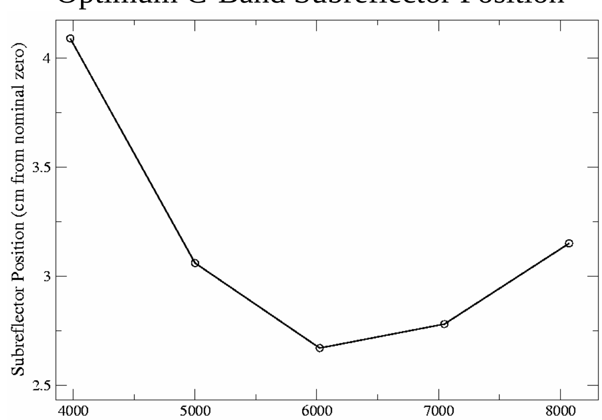
- New system has more spillover below 15 degrees elevation – due to higher overillumination of the subreflector
- Difference is less than 10K at 8 degrees elevation.



C-Band Focus

- As with L-band, the optimum subreflector position varies with frequency
- Minimal loss from wideband single-focus observing, when in optimum position.

Optimum C-Band Subreflector Position

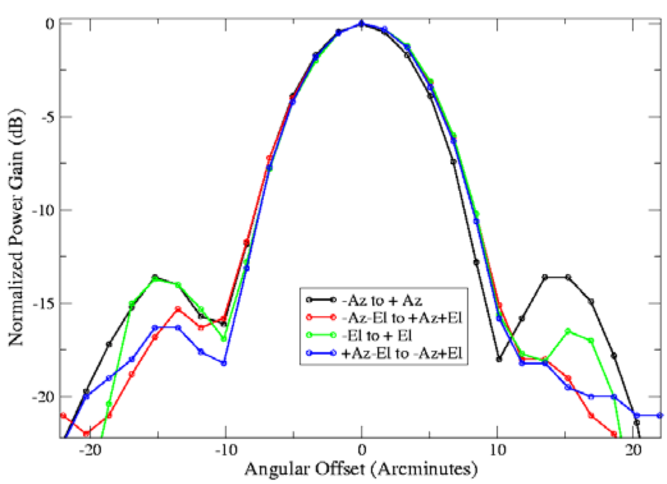


Efficiency

- Because of varying problems with pointing and resolution, we haven't gotten a fully satisfactory dependency of efficiency with frequency.
- All values run from 0.50 to 0.69, but most are between 0.55 and 0.65.
- Median value is about 0.60, across the whole band.
- Need better pointing and a nice point source for a more accurate determination.
- This will require stabilizing the gain for TP obs.

Beam Shape

- C-Band Beam looks about normal, with normal sidelobes.
- Possible asymmetry in elevation sidelobes, and in azimuth width.



C-Band Feeds, Summary

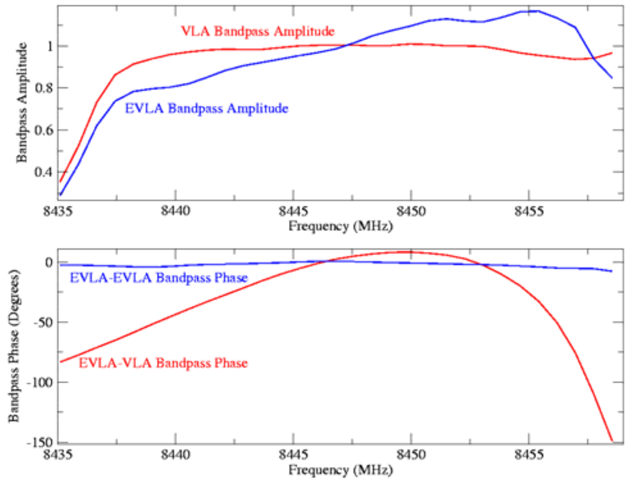
- Although the data are not quite as good as we would like, we can conclude:
  - C-Band feed has good efficiency over the whole of the 4 GHz bandwidth (4 – 8 GHz)
  - Ground spillover is higher than the old feed, but only at very low elevations.
  - Even at the lowest elevation, the SEFD of the new feed will be better than the old, since Tsys is expected to decline by ~10K.
- We intend to proceed with the procurement process for this feed.

Interferometer Tests (Barry and Ken)

- First fringes for antenna 13 were found in March 2004.
- Problems noted immediately:
  - No fringe tracking – had to put Ant. 13 at the array center.
  - Very large, non-linear (hence, not delay) phase gradient across the bandpass.
- First problem now solved!
- Second problem quickly determined to be due to the VLA's electronics – not an EVLA issue.
- This is a **transition issue**, for wide-band continuum observing.

EVLA Bandpasses

- These were first obtained Dec 2, 2004.
- Confirmed the bandpass phase origin.
- Can modify amplitude and phase bandpasses by digital means for transition observing.

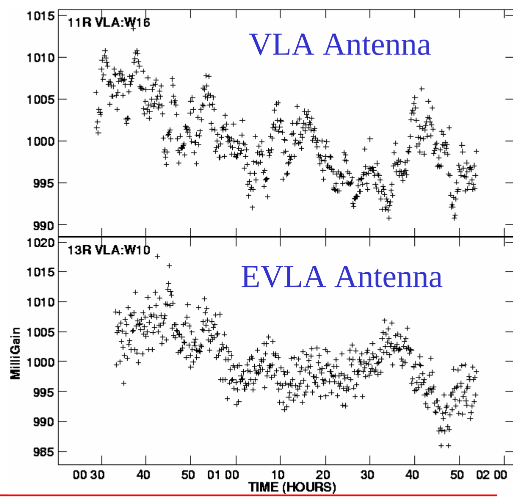


Visibility Stability

- Amplitude Stability
  - Clearly dominated (at X-band) by pointing errors on long timescales.
  - Short timescale `glitches' (few minutes) seem to be occuring.
  - Latter problem makes determination of accurate pointing difficult.
  - This is not expected to be difficult to solve.

Observed Amplitude Gains

- From Dec 9 data.
- Antenna 11 is adjacent to 13.
- Visible 'structure' due to high winds.
- EVLA antenna gains `fuzzier', but overall very good.

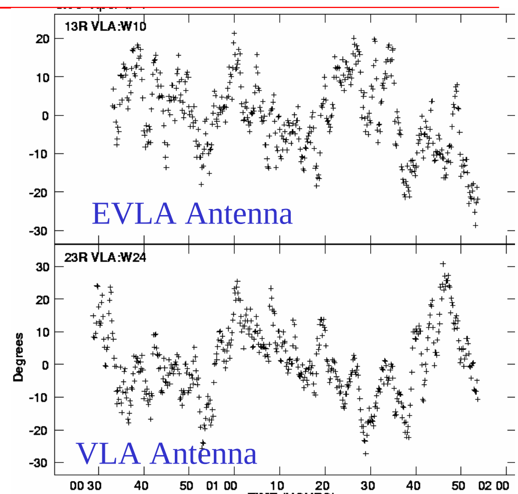


Phase Stability

- Determination of long-term phase stability characateristics is currently limited by general lack of robustness.
- Short-term rms phase stability is close to, but somewhat more than, the VLA – will require more careful measurements.

Phase Stability – 1 hour

- 90 minutes of X-band data, referenced to a nearby antenna.
- Slow drift in EVLA antenna removed (due to baseline error).
- Phase structure due to windy day – equal in both.



EVLA Antenna Checkout

- Besides these fundamental tests (which are organized by me), we will need a standardized checkout procedure.
- A hardware checkout procedure has been developed by the engineering groups.
- An operational checkout list is being organized by Chris Carilli.
- Chris will likely direct this effort.

Polarization

- EVLA requirement is to generate circular polarization within the cooled front-end.
- For low frequency bands (L, S, C, perhaps X), this will be done via commercial quadrature hybrids, located inside dewer.
- Lab measurements show low cross-polarization response.
- Sky measurements (very preliminary) do not agree.

Linear Fall-Back?

- If the quad hybrids are unacceptable, can we go to linear polarization?
- In principle, can do. But
  - High frequency bands would remain circular, so the EVLA would be a mixed-basis instrument.
  - More complex calibration required, especially for snapshot observations.
  - Major transition issue (VLA must remain circular).
- Careful measurements and study required, before an informed decision can be made.