EVLA Front-End CDR

On the Sky Tests
Proof of the Pudding …

• Engineering can’t rest until the scientists are happy!
• To have happy scientists, the telescope performance must meet the basic requirements.
• Extensive testing is ongoing to test on-the-sky performance.
System Temperatures

• Hot/Cold load tests done at L, C, K, and Q bands.
• For L and C, cold load was on sky – requires spillover assumption.
• For K and Q, liquid nitrogen cold load permits full calibration.
• For all bands, sky dips from 90 to 8 degrees done to measure spillover contribution.
Tsys Results:
L and C Bands

- L-Band (antenna 13, with prototype horn).

<table>
<thead>
<tr>
<th>Freq (MHz)</th>
<th>Tsys</th>
</tr>
</thead>
<tbody>
<tr>
<td>1325</td>
<td>27</td>
</tr>
<tr>
<td>1425</td>
<td>26</td>
</tr>
<tr>
<td>1675</td>
<td>32</td>
</tr>
</tbody>
</table>

- C-Band (antenna 14, using VLBA polarizer)
  - At 4850 MHz, Tsys = 23K
C-Band Tip Results

- Spillover contribution varies very little for elevations above 20 degrees.

EVLA spillover below 20 degrees greater than narrowband VLA feed.
L-Band Elevation Dependence

- EVLA L-Band system has greatly superior elevation performance!
System Temperatures
K and Q Bands

- On antenna 14, a complete set of measurements were possible.
- Tsys is for the zenith, under dry conditions.

<table>
<thead>
<tr>
<th>Freq.</th>
<th>Tr</th>
<th>Tsys</th>
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<tbody>
<tr>
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<td>70</td>
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<tr>
<td>48048</td>
<td>39</td>
<td>95</td>
</tr>
</tbody>
</table>
L-Band Polarization

- Requirements are set to give a spurious linear polarization of <5%
- The major spurious polarization contribution is due to the sum of two complex `D’ terms:
  \[ R_{rl} = I(D_{rl} + D^*_{l2}) \]
- The `D’ value is due to amplitude and phase imbalances.
- The sum can be made close to zero with good design. (But small \(|D|\) is better!)
L-Band Results

- Antennas 13-16 with VLA OMT.
- Red = on-sky measurements
- Blue = Prediction from Lab measurements
- Spike near 1450 MHz due to ‘suck-outs’ in VLA OMT.
More Results

- Antennas 14 x 16.
- Higher polarization on-sky is expected, as contribution of antenna itself is not in lab measurements.
- High values near 1460 MHz due to VLA polarizer, and will be eliminated with new design.
Bandpass Stability

- Requirements are that bandpass amplitude be stable to .01% over timescales of 1 hour, on frequency scales < 0.1% of the RF frequency.
- Bandpass phase stability better than 0.007 degrees on same scales.
VLA Amplitude
Differential Hourly Snapshots

• VLA antenna 17 amplitude.
• Ripple due to waveguide reflections.
• Magnitude ~ 0.5%
• Typical for all VLA antennas.
VLA Phase

- Showing VLA ripple in phase.
- Magnitude \( \sim 0.5 \) 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.
Some Conclusions

• Tsys meeting (or beating!) specs at all bands.
• L-band elevation performance superior to VLA.
  – Other bands elevation performance acceptable.
• L-band cross-polarization from hybrid looks good
  – but full frequency range tests needed with new OMT in place.
• Bandpass shape/stability much better than VLA,
  but not at spec level yet.
  – Limiting factor likely VLA’s baseband filters. Final tests must wait for WIDAR correlator.
• Scientists are (or will be) happy!