Prototype Correlator Testing

EVLA Advisory Committee Meeting, March 19-20, 2009

Michael P. Rupen
Project Scientist for WIDAR

Atacama Large Millimeter/submillimeter Array
Expanded Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array

NRAO

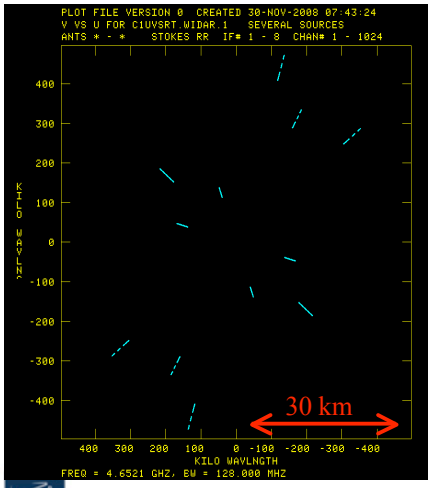
EVLA

Prototype Correlator

- 4 antennas
- 1 GHz @ 8-bits, RCP only
  - 4-bit re-quantization
- 8 x (8-128) MHz subbands
  - 128 MHz: 1024 x 125 kHz per subband
- Dumptime 0.05-1 sec
  - up to 7 MB/s
  - 1.4 GB/hr with 1sec dumps
- Longest observations ~10 hours
- No on-line flagging
- No Tsys
- No referenced pointing
- CBE writes raw data scaled by data valid & FFT'd

NRAO

4-station PTC



- W48 = ea17 10.5km
- N16 = ea18 1.4km
- E72 = ea23 21.0km
- N48 = ea26 9.4km

Critical On-the-sky Tests

- Primary purpose of Prototype Correlator (PTC)
- Designed to check for *hardware* problems, before going to full production
- Test plan originally outlined by Carlson (2006)
  - Reviewed and revised by NRAO (December 2007)
  - Final form: Rupen (2008)
- Carried out June-Dec 2008, culminating in successful WIDAR CDR

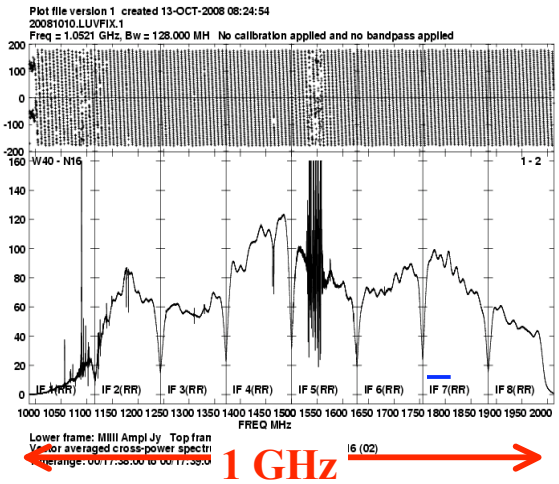
EVLA

Overview of PTC CotS Tests

- Dynamic fringes at 1, 5, 8, 22, 45 GHz
- “Plug-&-play”
  - D to A configuration
  - Antenna changes
  - New StB
- Phase & delay continuity when changing sources, frequencies, bands
- Closure phase and channel/time averaging
- Recirculation
- Deep integrations: high dynamic range (72,800:1), blank field
- Deep spectral line integration (3C84 HI)
- “Micro”SDM+BDF to move data into CASA & AIPS

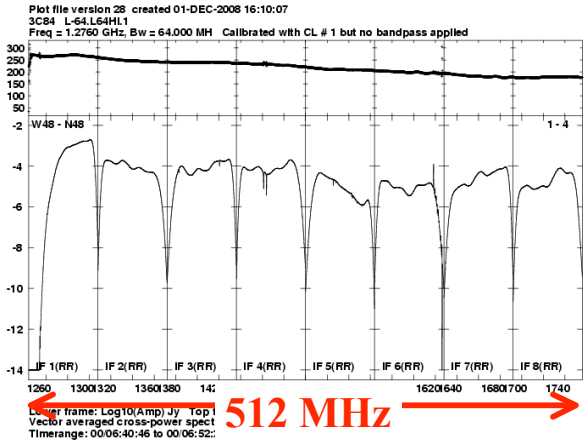
EVLA

1-2 GHz: continuum + RFI



EVLA

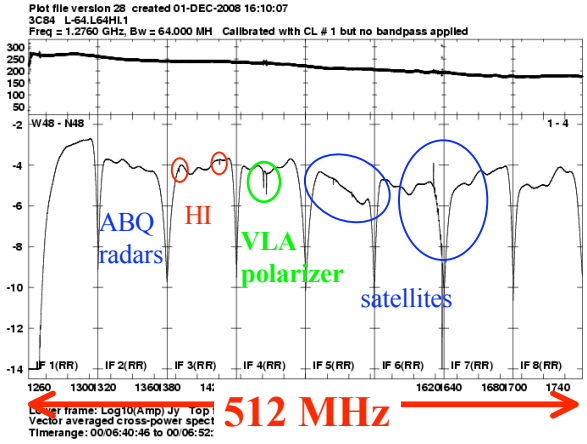
3C84 @ 1.5 GHz



- 1244-1756 MHz
- 8192 x **62.5 kHz** (13 km/s for local HI)

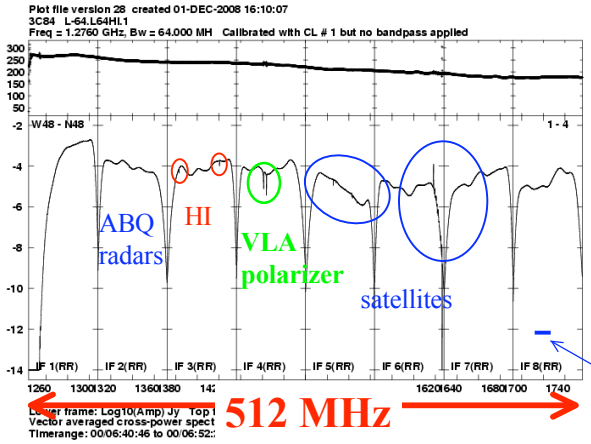
EVLA

3C84 @ 1.5 GHz



- 1244-1756 MHz
- 8192 x **62.5 kHz** (13 km/s for local HI)

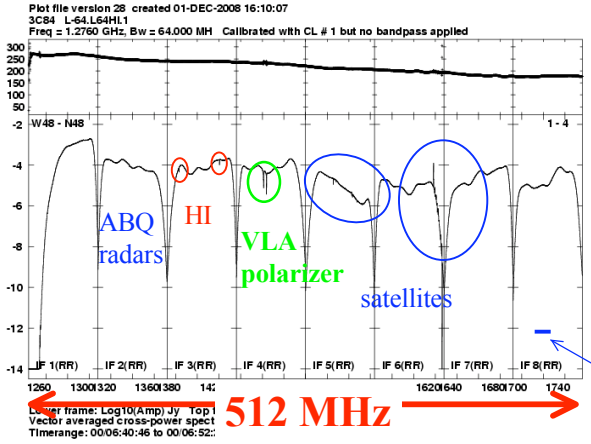
3C84 @ 1.5 GHz



- 1244-1756 MHz
- 8192 x **62.5 kHz** (13 km/s for local HI)

Current VLA: 6.25 MHz @ 98 kHz

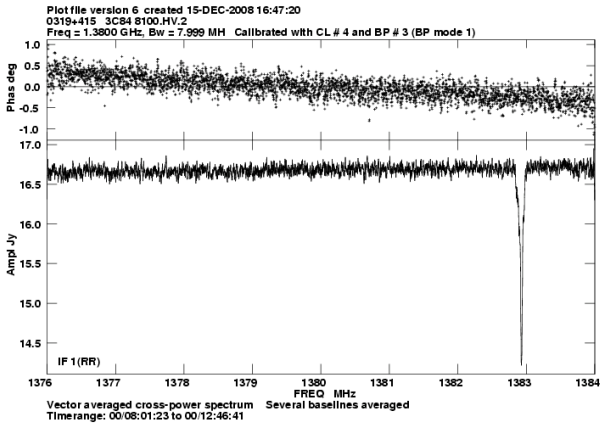
3C84 @ 1.5 GHz



- 1244-1756 MHz
- 8192 x **62.5 kHz** (13 km/s for local HI)
- Final EVLA:
  - **512 MHz (z=0-0.3)**
  - **@ 7.8 kHz (1.7 km/s)**

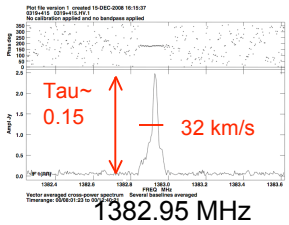
Current VLA: 6.25 MHz @ 98 kHz

3C84 @ 1.5 GHz

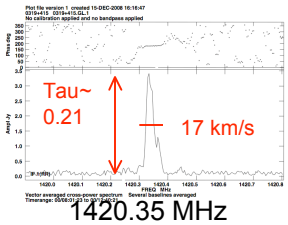


- 1376-1384 MHz (one 8 MHz subband)
- 4096 x 1.95 kHz (0.4 km/s)

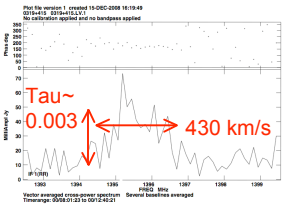
3C84 @ 1.5 GHz



1382.95 MHz



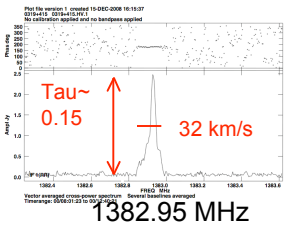
1420.35 MHz



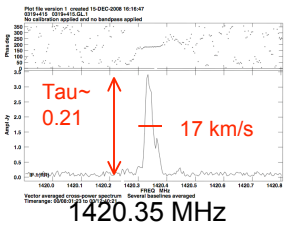
1395.5 MHz

- 8 x 8 MHz subbands
- 8 x 4096 channels
  - Avg'd x2 (3.9 kHz)
  - or x64 (470 kHz)
- Zoomed in here!

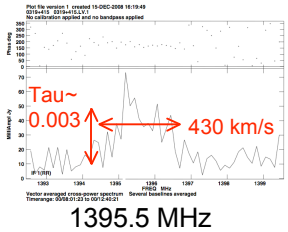
3C84 @ 1.5 GHz



1382.95 MHz



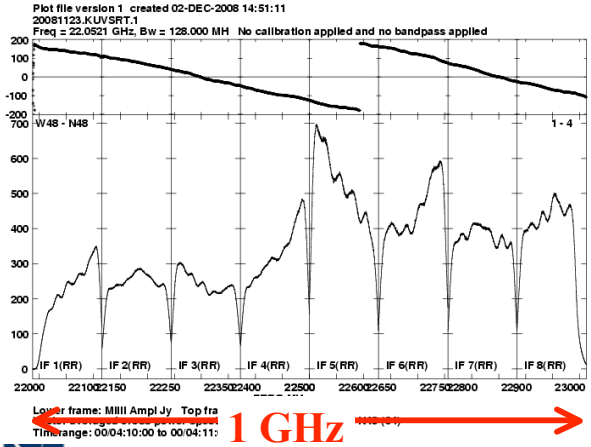
1420.35 MHz



1395.5 MHz

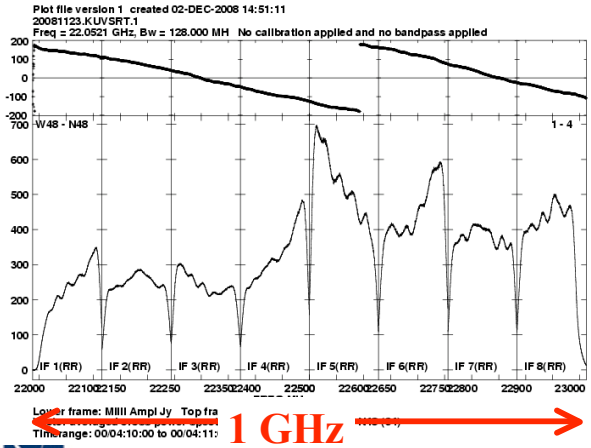
- 8 x 8 MHz subbands
- 8 x 4096 channels
  - Avg'd x2 (3.9 kHz)
  - or x64 (470 kHz)
- Zoomed in here!
- Full EVLA:
  - 64 **independently tunable** subband pairs
  - **Different bandwidth & resolution** for each subband pair

3C84 @ 22 GHz



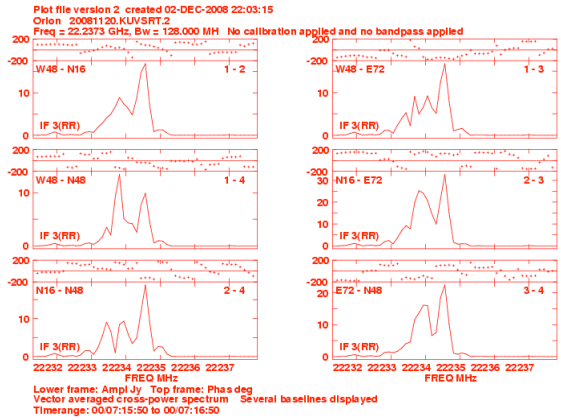
- 21988-23012 MHz
- 8192 x 125 kHz (1.7 km/s)

3C84 @ 22 GHz



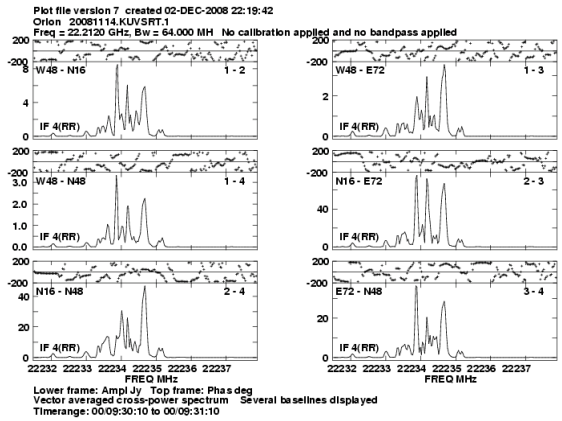
- 21988-23012 MHz
- 8192 x 125 kHz (1.7 km/s)
- Full EVLA:
  - **8 GHz** (BWR 1.5:1)
  - **Full pol'n**
  - 8192 x 1 MHz (14 km/s)

Recirculation: Orion water masers



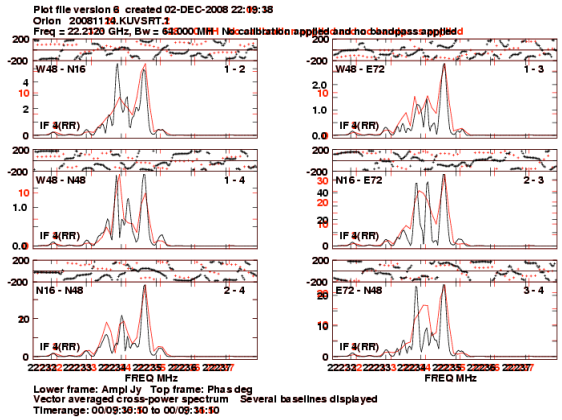
- 128 MHz, no recirc.
  - 125 kHz/channel

Recirculation: Orion water masers



- 128 MHz, no recirc.
  - 125 kHz/channel
- 64 MHz, x2 recirc.
  - 31.25 kHz/channel
- 1.4% shown here

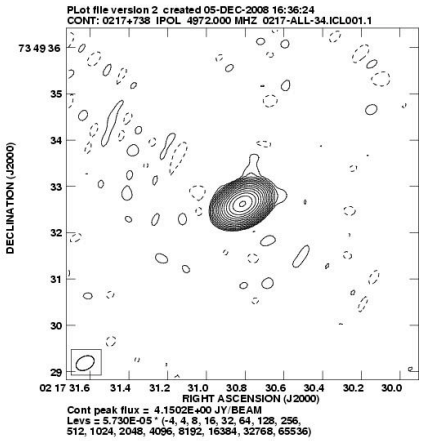
Recirculation: Orion water masers



- 128 MHz, no recirc.
  - 125 kHz/channel
- 64 MHz, x2 recirc.
  - 31.25 kHz/channel
  - Smoothed to match

EVLA

Image not limited by closure errors

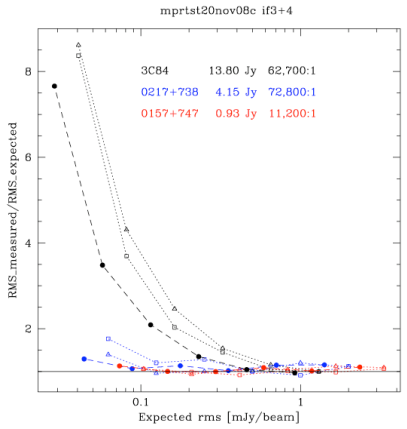


- 0217+738
  - 4 Jy "dot"
  - 2hr10min on-source
- 4588-5612 MHz
- Self-cal'd image
- Peak:rms= 72,800:1

NRAO

EVLA

Deep images of strong calibrators



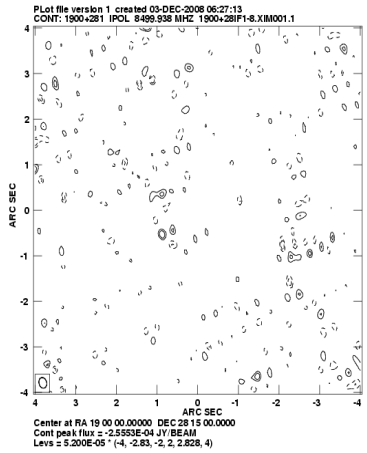
△ 4844-4972 MHz
□ 4972-5100 MHz
● 4844-5100 MHz

- 3C84: 5.2 hours
- 0217+738: 2.2 hours
- 0157+747: 0.8 hours
- N.B. noise matches SEFD to 10% !

NRAO

EVLA

Deep image of a blank field



- J1900+2815
- 9012-7988 MHz
- 2.3 hours on-source
- Rms in 125 kHz: 2.84 mJy/beam
- Rms in 103 MHz (825 channels): 0.11 mJy/bm
- Rms in 825 MHz (825x8 channels): 0.052 mJy/bm

NRAO

EVLA

Backup slides

NRAO

EVLA

PTC CotS Tests: The List

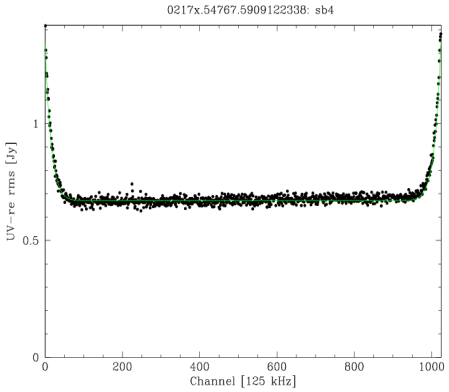
- 2.1 Fringe check with delay tracking
  - Phase, delay vs. time
  - Autocorr'ns, state counts, etc.
- 2.2 Phase continuity
  - Phase, delay consistent when changing sources, frequencies, bands
- 2.3 Closure
  - Stability for hours
  - Integrates down with time and frequency averaging
  - Clean images
- 2.4 Deep continuum observation
  - 10 hours

EVLA

PTC CotS Tests: The List

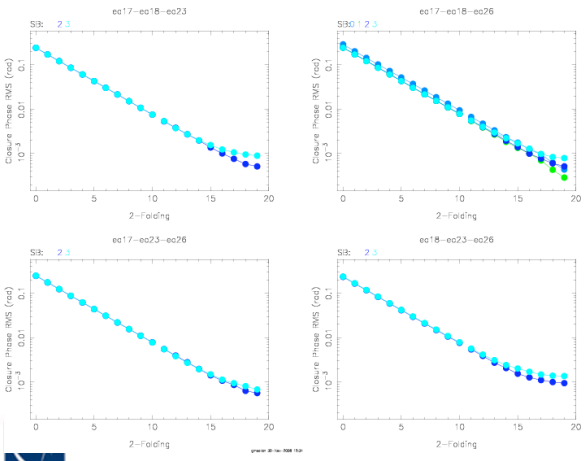
- 2.5 Spectral line consistency
  - Different subband bandwidths
- 2.6 Subband aliasing
  - Leakage between subbands
- 2.7 Recirculation
- 2.8 Deep spectral integration

Filter response



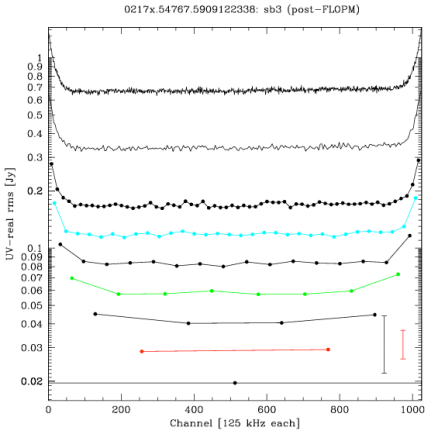
- 0217+738
  - 4 Jy "dot"
  - 40min on-source
- 7656-7784 MHz
  - Subband 4
  - 128 MHz: Stage 1 only

Closure phase: averaging down



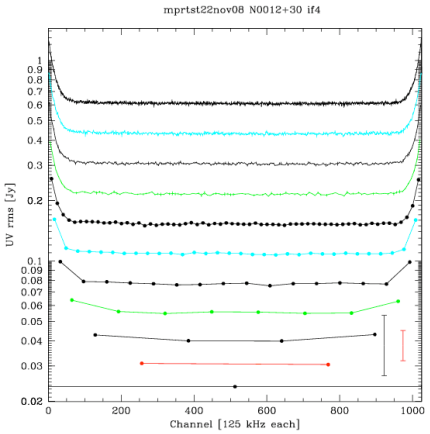
- 0217+738
  - 4 Jy "dot"
  - 2hr10min on-source
- 4588-5612 MHz
- Averages down to 0.03-0.11 degs.
  - Avg x2 in freq, then time
  - DR~ 31,000:1
- Corresponds to pol'n leakage of a few %

Averaging down in frequency



- 0217+738
  - 4 Jy "dot"
  - 40min on-source
- 7784-7912 MHz
  - Subband 3
  - 128 MHz, 1024 channels
- Boxcar averaging by 4, 16, 64, 128, 256,…
- Within 1% of theoretical through box=64

Averaging down in frequency



- J0012+3053
  - 16 mJy "dot"
  - 2 hours on-source
- 8288-8416 MHz
  - subband 3
  - 128 MHz, 1024 channels
- Boxcar averaging: 2, 4, 8, 16, … channels
- Noise goes down by sqrt(2) within 1% through box=64