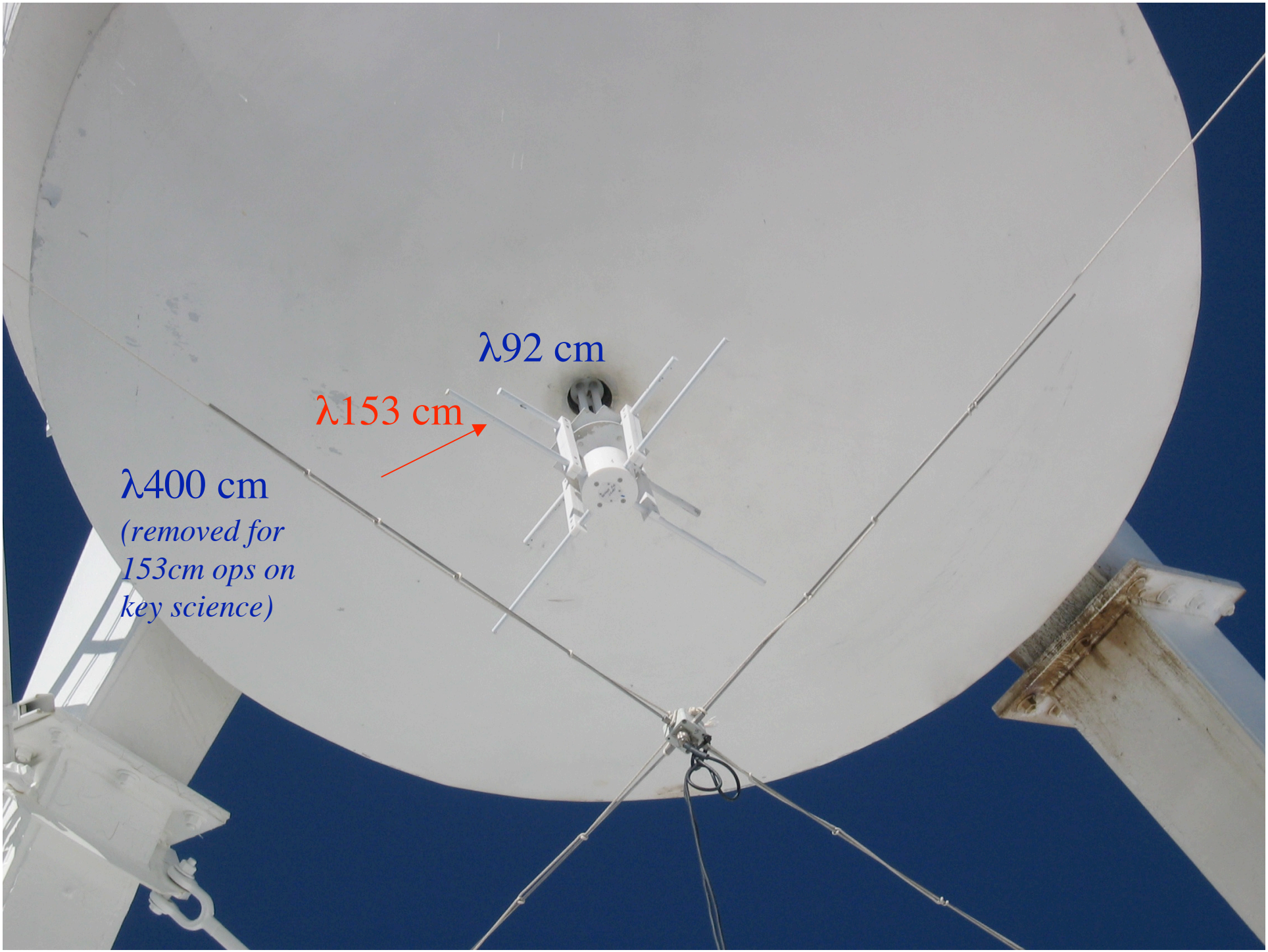
The Proposed VLA VHF Extension

Field and Lab Test Results, Design Updates, and Deployment Plans

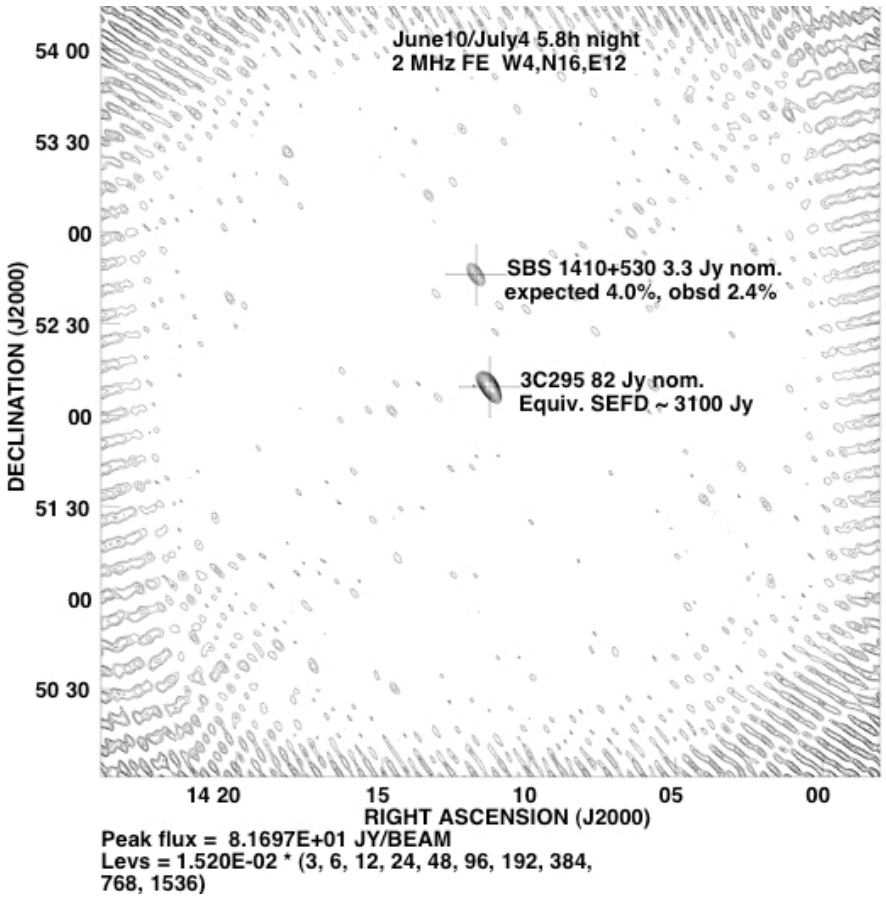
- Enables timely (key) research in cosmology
  - raises profile of VLA/EVLA
  - puts VLA on par or ahead of other low-ν facilities
    - LOFAR (science data from core in 07)
    - PAST (science data in 07 - but polz. cal. constrained)
    - MWA (proposal pending; science data possible in 08)
  - expands EVLA low-ν capability
- Enables general user (legacy) science
- Brings together two active observatories
  - Hardware built by SAO receiver lab
- Acknwldg: J. McClendon, I. Ginsburg, R. Kimberk, S. Leiker, D. Mertely, L. Peritz, R. Smith, E. Tong, VLA Ops/SchedSOC

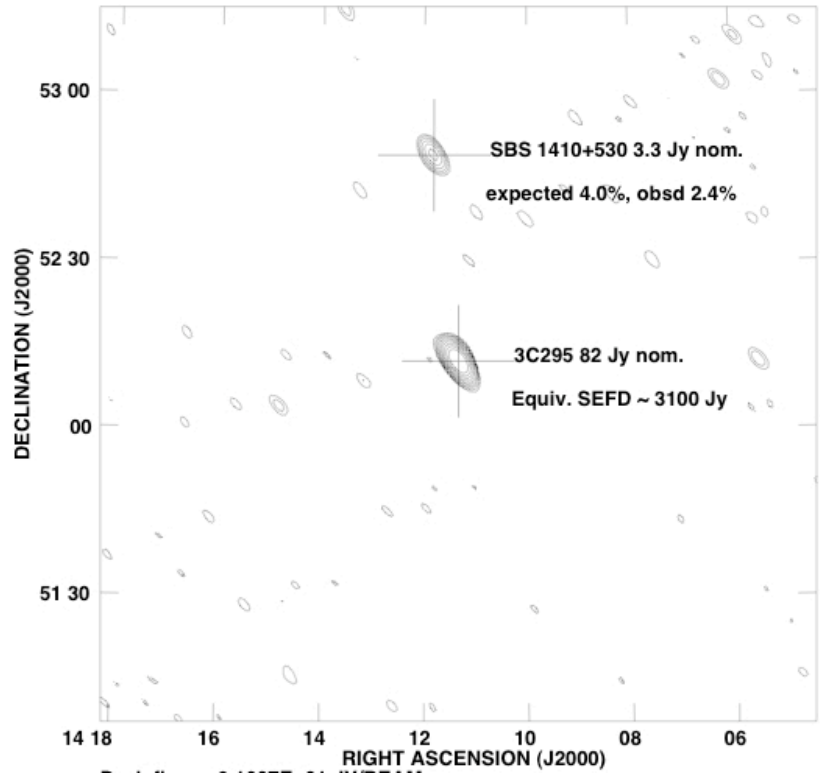

λ92 cm
λ153 cm
λ400 cm
(removed for 153cm ops on key science)

Status

- 3 element 195 MHz subarray in routine use
- Impact on VLA L and P-band: small
- RFI characterized; coordination effort begun
- Production RX designed
  - General user science band included
- No showstoppers yet regarding sensitivity
  - But addressing unknowns of high-dynamic range, high-sensitivity imaging in an intense RFI environment requires
    - production RXs
    - » 3 antennas
    - coordination with broadcasters

195 MHz Imaging





Timeline

- Aug 04 - Dec 04 Planning/Initial Feasibility
- Dec 04 - Feb 05 Prototype construction
- Mar 05 - Jun 05 Field testing *on site*
  - Jul 05 - Sep 05 Remote field testing, follow-up
- 27 Jul 05 NRAO design/logistics review
- Aug 05 - Nov 05 Hardware Production
- Oct 05 - Nov 05 Deployment (4 RX/wk)
- Dec 05 First science time/proof of concept

Field Test Activities

- 1.5m performance
  - Total power G/T
  - Cross power G/T
  - Holography
  - Cross polarization
- L-band / P-band performance impact
  - Tsys (L)
  - G/T (L, P)
  - Beamwidth (P)
- RFI characterization
  - Mitigation planning
  - Coordination investigation
- Assessment of key and legacy science feasiblity

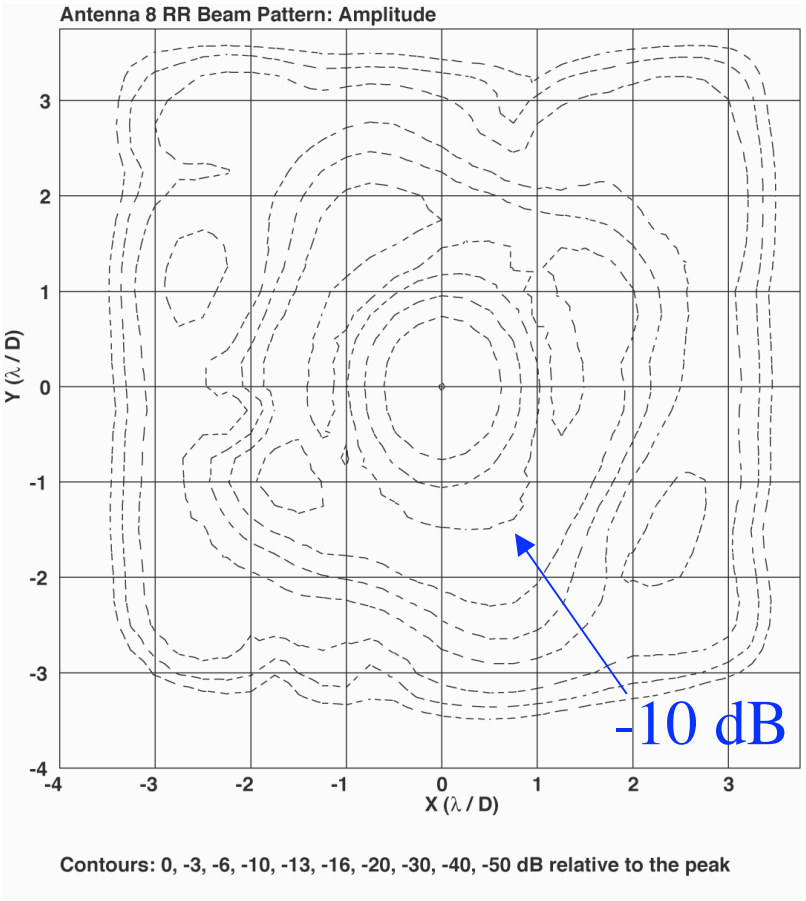
VLA Prototype Performance

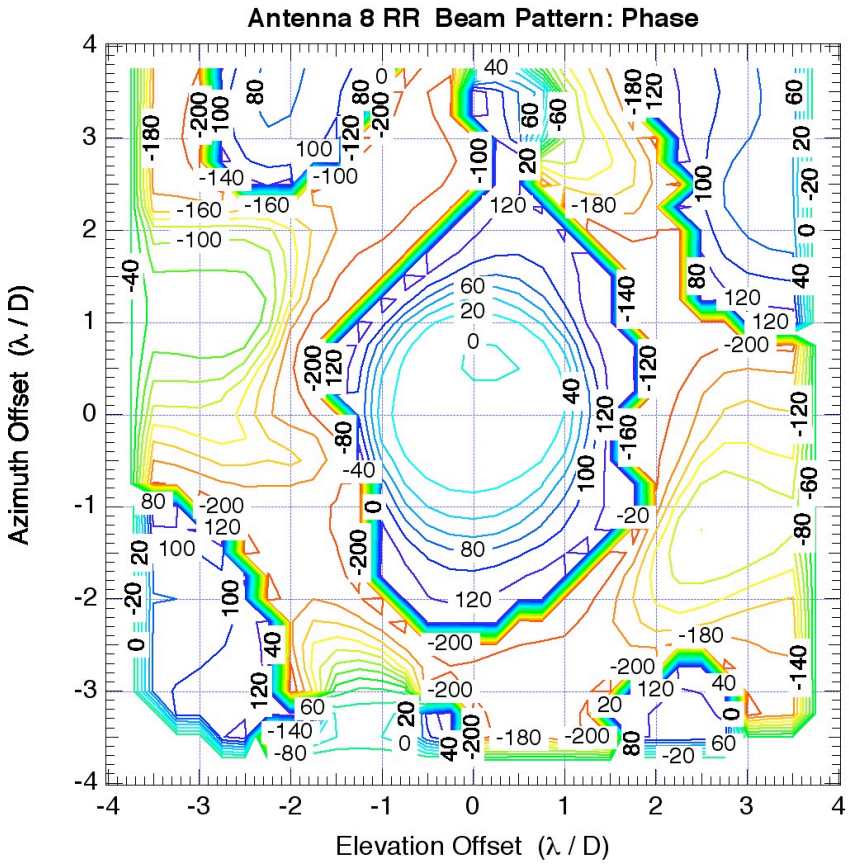
	Measured	Goal	Anticipated
Primary Beam	4.3°	√	--
Beam sidelobes	~10 % @ λ/D	a few %	< 10%
T_{sys} / ε	600-800 K (†)	400-500 K	~500-700 K (††)
Receiver X-polz	10-40%	10%	match P-bnd
Line RMS/450^h	~6-8 mK@15′	a few mK	~ 4-5 mK(§)
Impact: λ20cm Impact: λ92cm	0 ± 1% 0 - 10%	≤ 1% < 5%	0±1% 0%

† Corresponds to ε~ 30%; T_{sys}~200 K (195 MHz). Wb obtains ε~ 30%; Tsys~400 K (150± MHz). †† Contingent on deployment options TBD.

§ Depends on correlator mode, observing strategy, RFI; see later discussion

195 MHz Holography

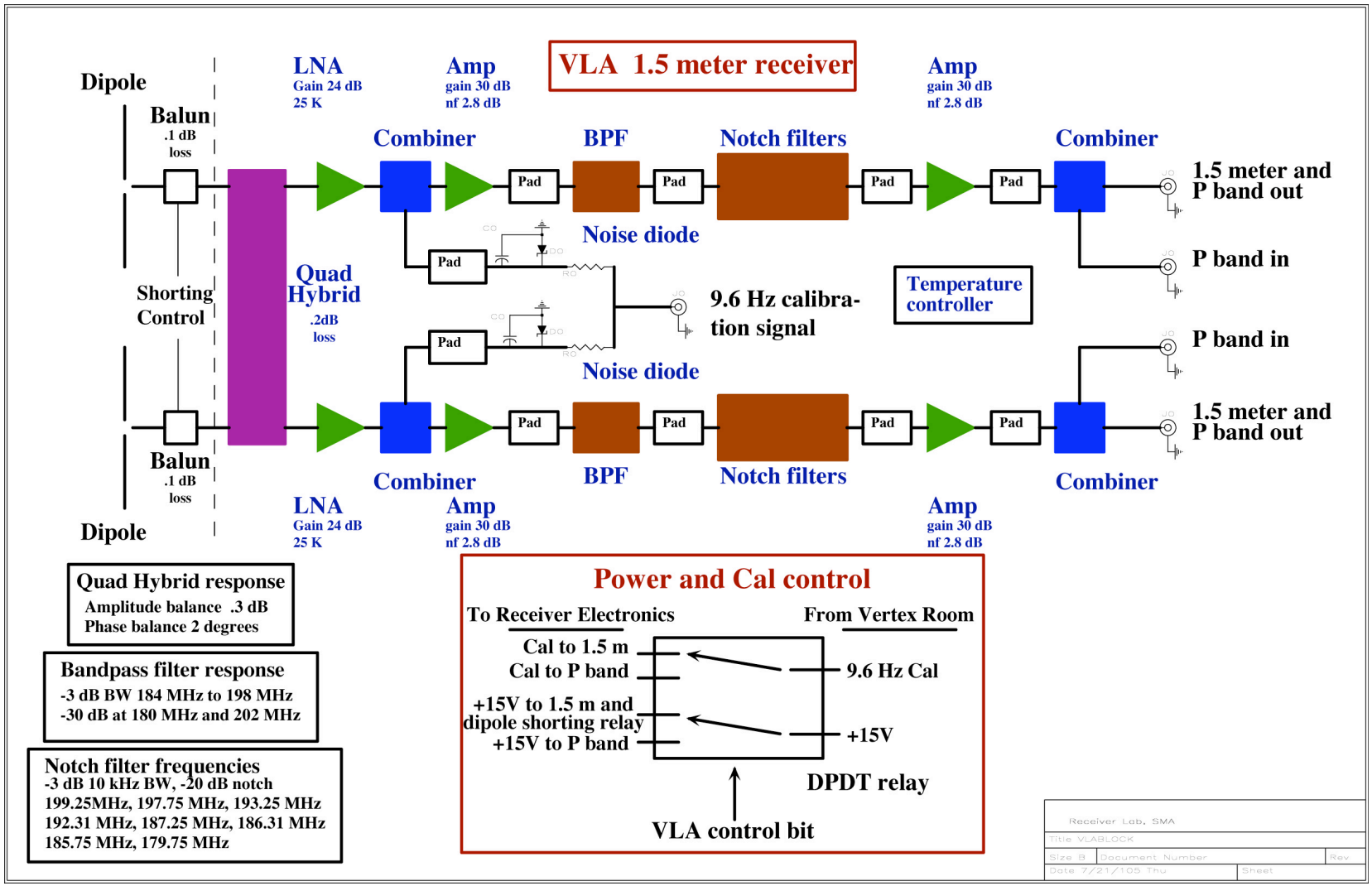




RX Design Changes

Component	Change	Driver
Q-hybrid	Move to before LNA; broader band, lower loss component	Purity of polarization; isolation of LNA from mismatches
LNA	Operating point	Higher gain, lower T_{RX}
Noise diode injection	Move to after LNA; off for science observations	Stability; low T_{RX}; preclude leakage into P-band receiver
Lumped-element balun	Replace coaxial balun	Low insertion loss, broad bandwidth
Bandpass filter	Use 8-pole custom filter	Exclusion of TV carriers
High-Q crystal notch filters	Inclusion	Exclusion of TV carriers to enable operation of ALCs and to avoid ringing in spectra
Dipole shorting switch	Inclusion	P-band performance.
Connection to superflex	3 dB pad at 2-band RX out	Damp 3 MHz bandpass ripple in 1.5m AND P-band output
2-band / P-band power and cal on/off control *(PROPOSED)*	S/W control of power and cal signal to 2-band and P-band *(PROPOSED)*	Noninterference assured. 2-band off for P-band obs. P-band off for 2-band obs. Control power at A-rack input

Layout of Production RX



Production RX Performance

Production Receiver Characteristics

Bandwidth	Total: 184-198 MHz @ -3 dB set by bandpass filter [Q-hybrid: 160-230 MHz Feed: 193 MHz optimized, $\Delta\nu/\nu \sim$ 5-8%]
Gain	84 dB with pads and ground isolation betw. stages
Notches	TV 7(v), TV8(a), TV9(v), TV10(v,a) TV11(v), DTV9(c), DTV10(c)†
Power out	-67 dBm over 14 MHz at input to A-rack
Supply	15 VDC @ <1A; 15/28 V for cal.

† (a) audio, (v) video, (c) digital carriers

Anticipated Antenna Performance

Primary beam	~ 4.3° half power full width; 10 dB 1st sidelobe
Cross pol.	Comparable to P-band
SEFD	2400 – 4000 Jy (16 cm dipole spacing) 2000 – 3300 Jy (10 cm dipole spacing) †

† 2400-4000 Jy reflects 10% reduction in T_{SYS} enabled by improvements in receiver design. 2000-3300 Jy reflects further 15% improvement anticipated when short stand-offs are employed between 1.5m and 0.92m dipoles. Later slides treat this proposed configuration in greater detail.

Sensitivity and EOR Science

- Original RMS estimate [expect ~ 23mK × f(HI)]
  - 3.1 mK in 300^h@85% / 1.6 MHz line / 2200-2400 Jy / 26 antennas / dual pol. / 0.2kλ
- New RMS estimate
  - RFI excision⇒use mode 4 (1.56 MHz/24.4 kHz or 781 kHz/12.2 kHz)
  - BW loss/off-src subtraction: 1.4× (1.56 MHz) 2.0× (781 kHz)
  - SEFD: 1.1-1.7× (15.6 cm dipole spacing) 0.9-1.3× (10 cm spacing)
  - Drop lowest *z* target: 0.82× (450^h)
- Total Penalty (15.6 cm spcg) 1.3-2.0× (1.56 MHz)
  1.8-2.8× (781 kHz)
  Total Penalty (10 cm spcg) 1.0-1.5× (1.56 MHz)
  1.5-2.1× (781 kHz)
- Short of detection, likely 3σ upper limit on f(HI) anticipated
  - ~ 0.5 for average SEFD (10 cm/1.56 MHz)

Impact on L and P-bands

- L-band
  - T_{SYS} measured w/ dipole on/off on 2 days
    - Difference consistent with zero ±1K at zenith (T_{SYS}~30K)
  - G/T measured w/ dipole on/off on 2 days
    - Ratio for dipole on/off ~ 0 ±1% (CasA)
- P-band (ABSENT LOAD TESTS, HARD TO MEASURE)
  - Shorted 1.5m dipole (PREFERRED OPTION)
    - Improvement in G/T@327 MHz~7±5% (multiple beam cuts)
    - Some +ve bias possible due to 1.5m ND leakage in P-band
    - Finite element model predicts < 0.1 dB effect
  - Loaded 1.5m dipole (LESS HEAVILY STUDIED IN THE FIELD)
    - G/T for the test antenna is in the midrange of antennas
    - Finite element model predicts < 0.1 dB effect

Proposed Change to Feed Assembly

- Critical item for discussion with NRAO
- Dipole gain are sensitive to their separation
  - Affects forward gain and impedance at balun input
  - Current spacing, Δ=15.6 cm
- Gain at 1.5m can be improved ~10% for
  - 10 cm spacing
  - P-band remaining $\lambda/4$ from the subreflector
  - Reduction in spill-over also possible (of order 10K effect)

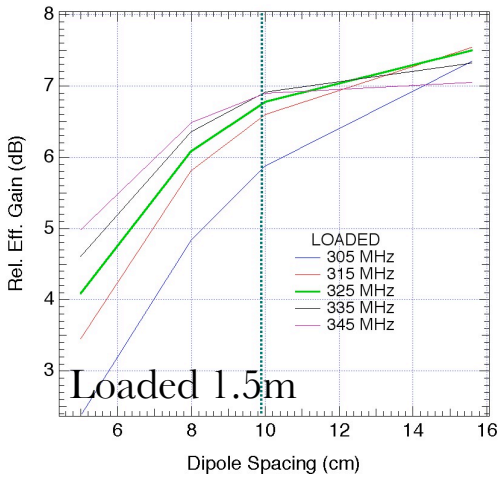
Distance (cm)	185 MHz (dB)	195 MHz (dB)
15.6	7.41	7.33
10.0	7.74	7.78
8.00	7.39	7.90
5.00	7.28	8.02

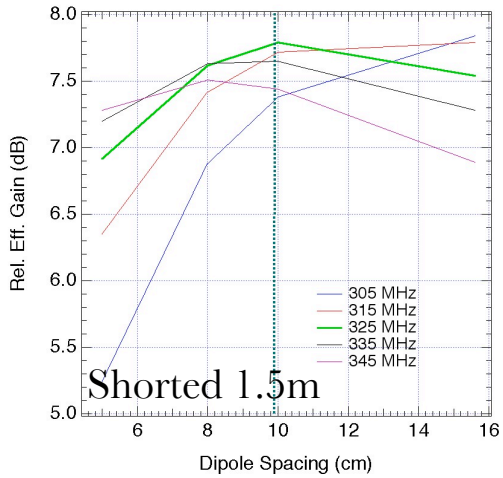
1.5m relative gains. Calculation assumes balun input matched at 195 MHz for all spacings since it can be customized during manufacture.

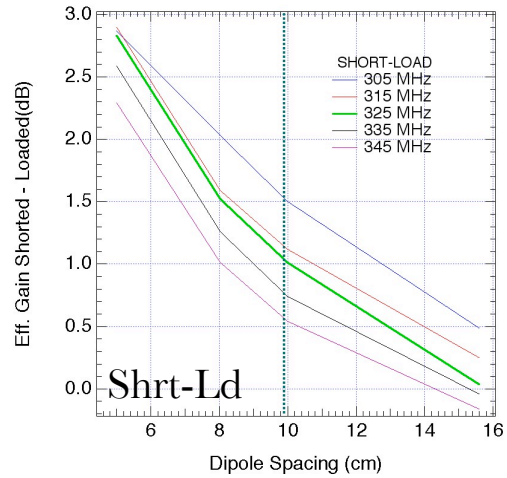
ν	1.5m loaded	1.5m shorted	Δ
305 MHz	7.35 dB	7.84 dB	0.49 dB
315	7.54	7.79	0.25
325 ††	7.50††	7.54	0.04
335	7.32	7.28	-0.04
345	7.05	6.89	-0.16

P-band relative gains. Gains account for balun mismatch that increases as spacing departs from 15.6cm. †† 7.55 dB @ 325 MHz w/o 1.5m dipole.

Varying Dipole Separation: Effect on P-band performance

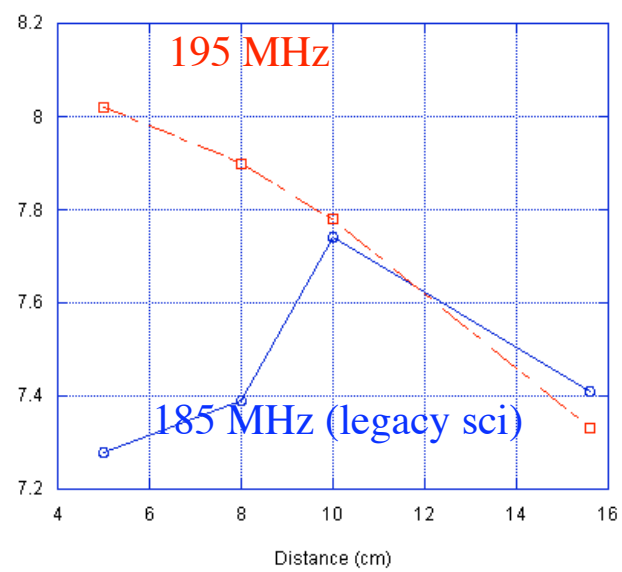




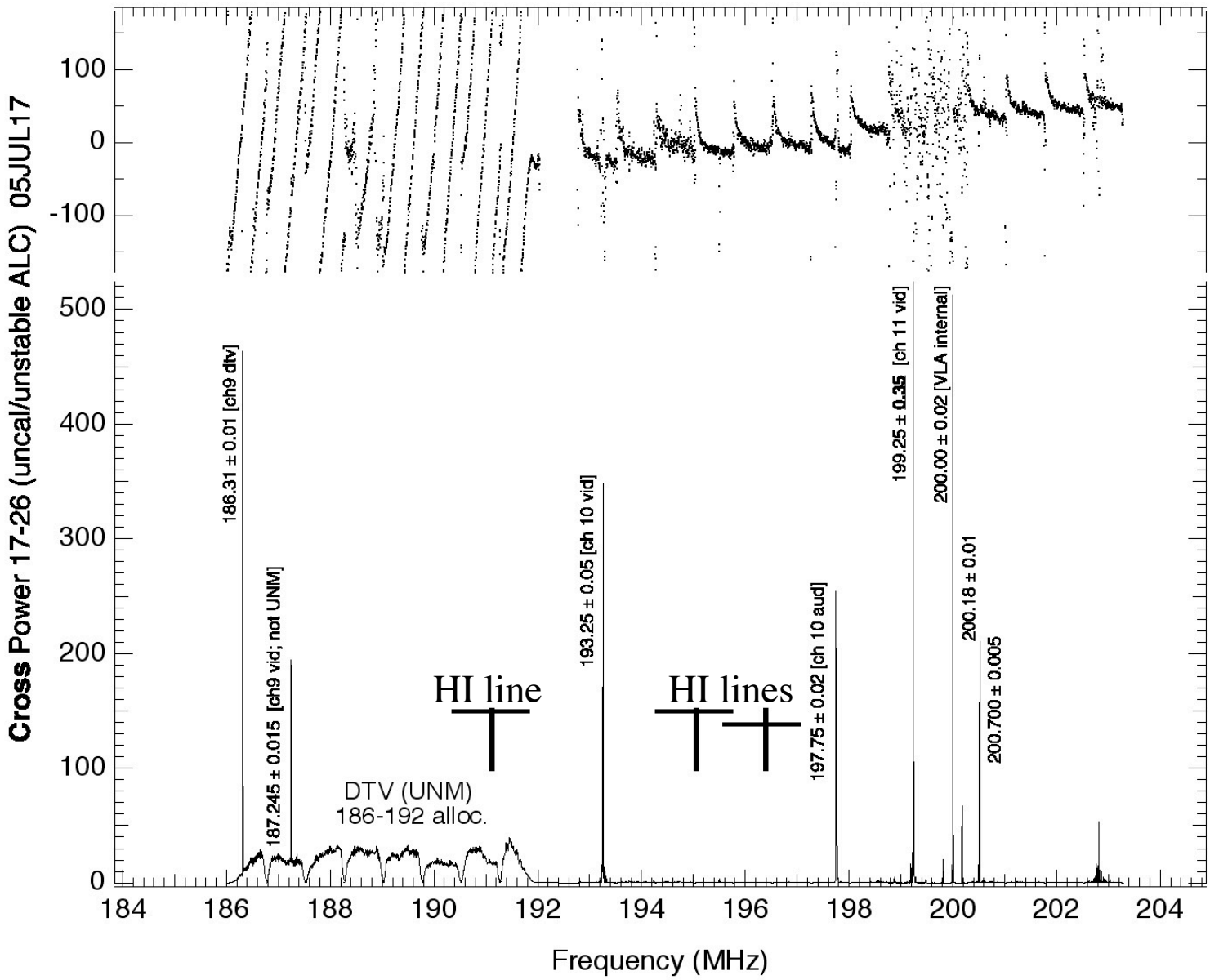


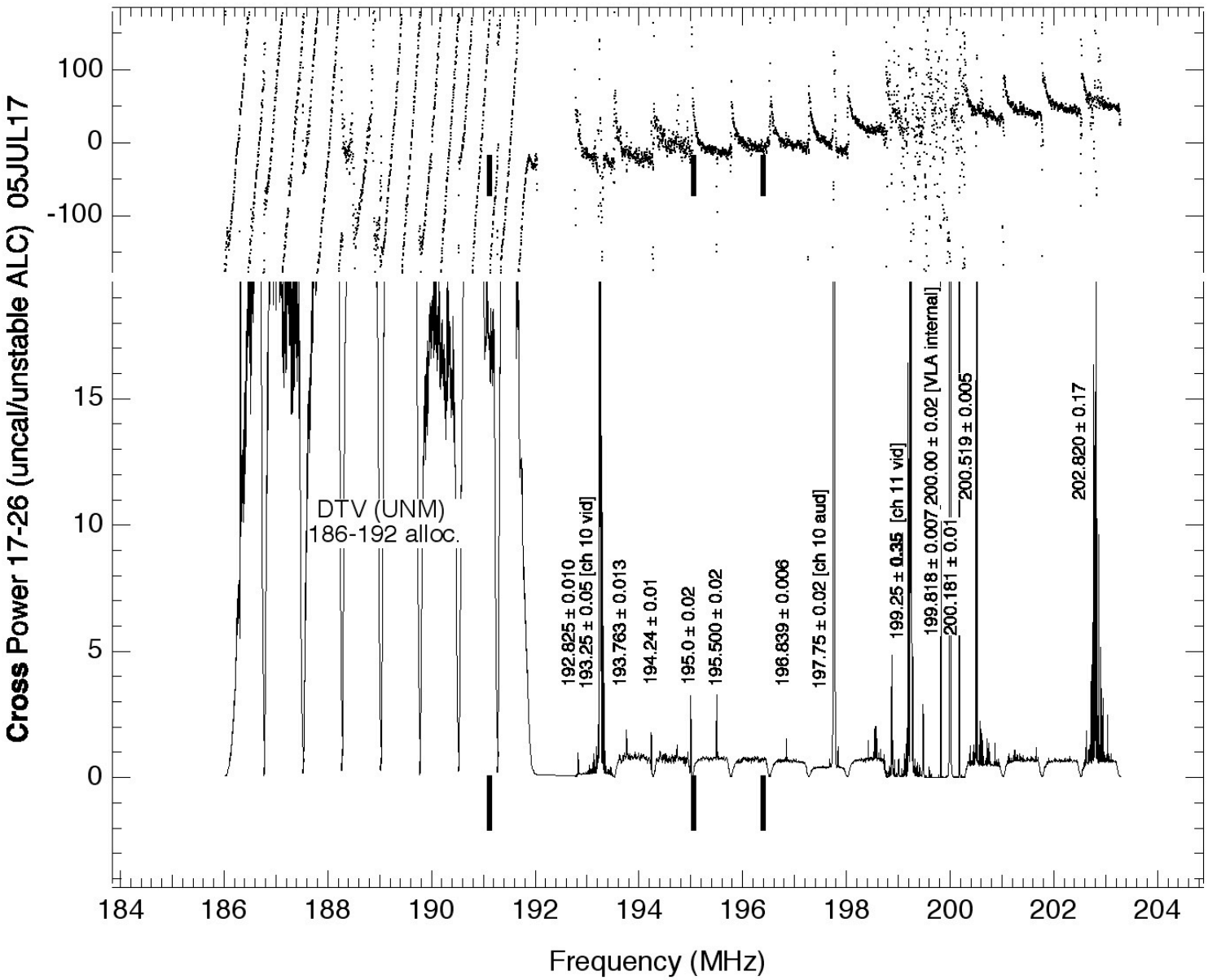
Effect on 1.5m performance

- Finite element model calc.
- Reflection losses tracked

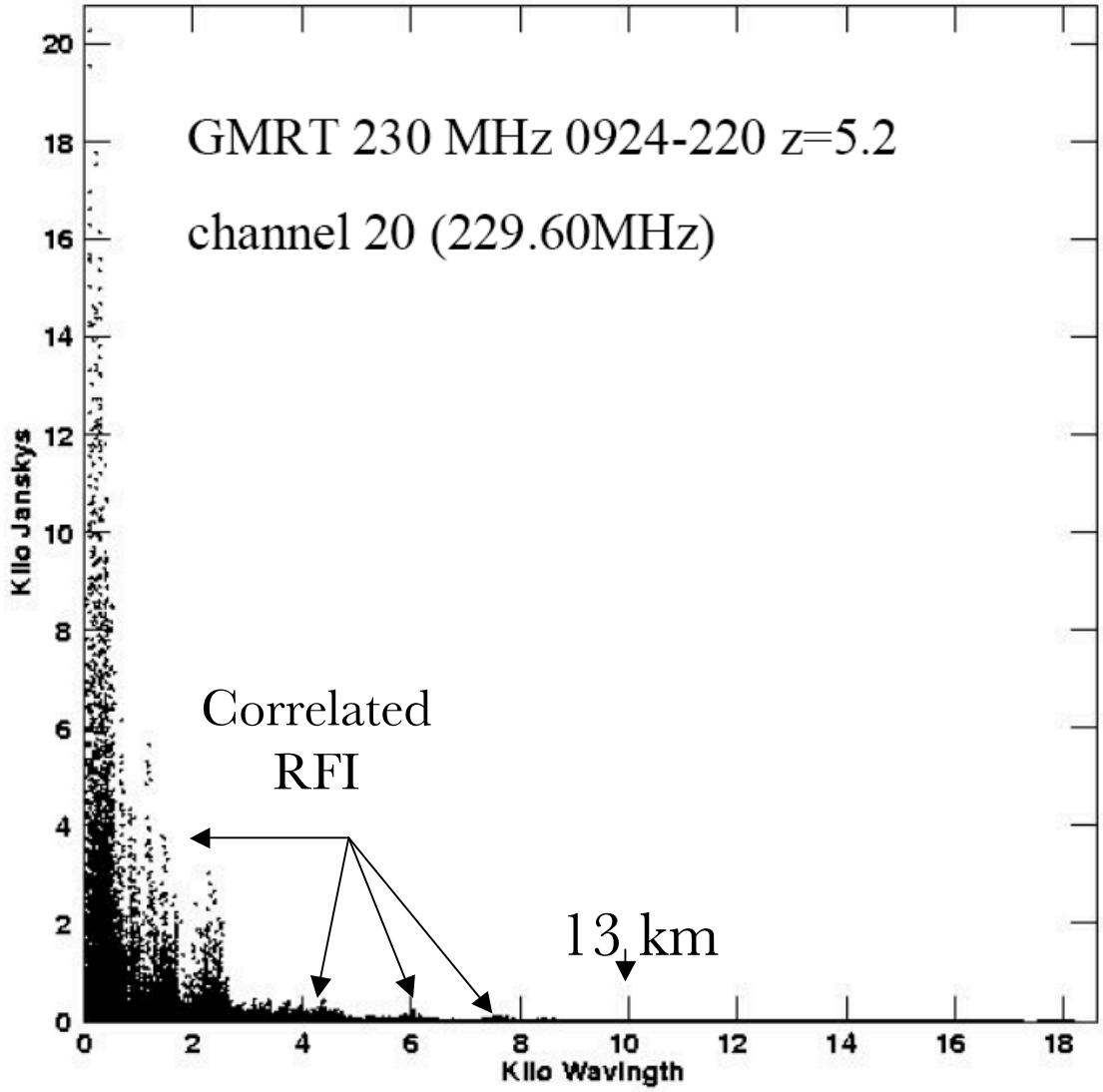


July 17 RFI Sweep




Cross Power 17-26 (uncal/unstable ALC) 05JUL17
100
0
-100
15
10
5
0
DTV (UNM)
186-192 alloc.
192.825 ± 0.010
193.25 ± 0.05 [ch 10 vid]
193.763 ± 0.013
194.24 ± 0.01
195.0 ± 0.02
195.500 ± 0.02
196.839 ± 0.006
197.75 ± 0.02 [ch 10 aud]
199.25 ± 0.35 [ch 11 vid]
199.818 ± 0.007
200.00 ± 0.02 [VLA internal]
200.181 ± 0.01
200.519 ± 0.005
202.820 ± 0.17
184
186
188
190
192
194
196
198
200
202
204
Frequency (MHz)

Immunity of Long Baselines to RFI



Deployment Logistics

- Priority: minimize use of NRAO manpower
  - Field testing relied principally on R. Smith, D. Mertely, and J. McClendon (to a lesser extent)
  - Heightened demand because of RFI impact on prototype
  - Demand greatly reduced over last 1-2 months
- Deployment window October 10-December 5
  - 4 RX/week on maint and s/w days (x Thanksgiving)
    - 15% contingency
  - Need 1 NRAO staff-equivalent
  - 2 SAO technical staff members available for barrel/manlift work
    - Install R and feed
    - DVM and RF reflection loss measurements.
  - 1-2 SAO staff members available for measurement/testing
  - 1 extra from SAO may be available for barrel work. TBD.
  - Carilli and Perley when available/practical

Deployment Logistics II

- Test deployment of short stand-offs
  - Clean swap of 1.5m feed assembly
  - Use cherry picker while barrel work ongoing at other antennas
    - ~1.5^h of correlator time to establish baseline @ 0.92m and 1.5m
      - G/T and beamcuts
    - Swap feed assembly
    - ~1.5^h of correlator time to establish shift @ 0.92m and 1.5m
      - G/T and beamcuts
    - Swap made after installation of receivers 1 & 2
    - Results available for NRAO consideration by the end of week 1
    - Deployment with long stand-offs through decision point in week 2
    - SAO will maintain necessary stock of assemblies for a "yes" or "no"
    - Removal of unnecessary feed assemblies (long or short) in parallel with later deployment work
- Test time required
  - 1^h at the end of day 2; 6^h at the end of week one (night)
  - 4-6^h at the end of every other week (night)
  - Schedule may require some review as experience is gained

SAO Action Items Following Successful Review

- Procurement
  - Closely monitor deliver and production schedule
- Draft RFI coordination agreement in writing
  - Begin coordination with DTV10 (KCHF) for testing at VLA
- Assess RFI subtraction using correlator data
- Review deployment logistics
  - Discussion of short stand-offs
  - Assess SAO and likely NRAO manpower
  - Draft step by step schedule of weekly activites
    - Establish contingencies
    - Assure realism
- Assess EVLA availability for 2005/06 tracks
  - 3 kW power supplies, P-band module readiness, shorting bit wiring
  - Evaluate UV coverage if down 5 antennas