

A Proposed VLA-VHF Rx System for Pathfinder EOR Science

L. Greenhill

- **Proposing team**

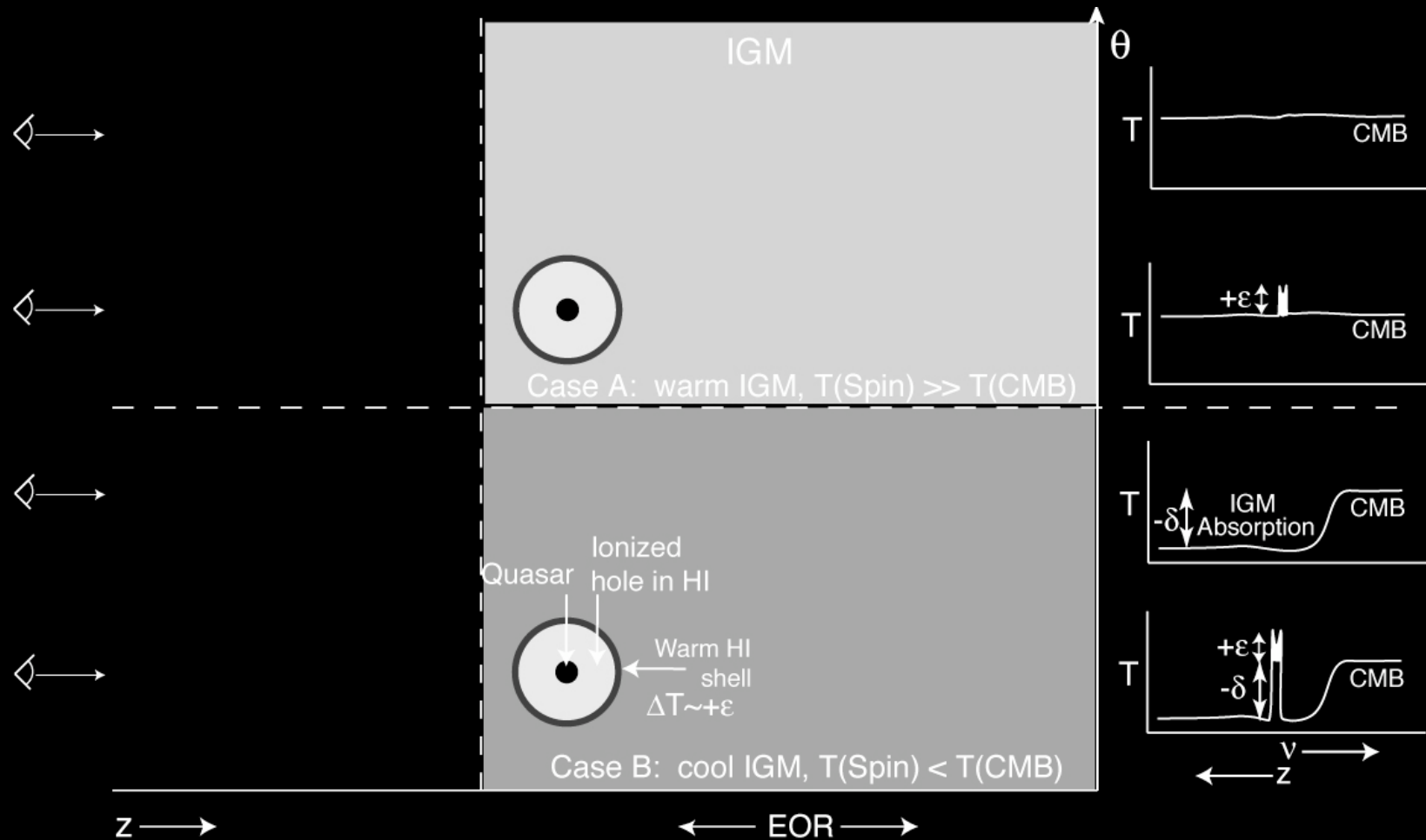
- L. Greenhill, R. Blundell (SAO)
- R. Perley, C. Carilli (NRAO)
- A. Loeb, M. Zaldarriaga (Harvard)
- S. Furlanetto (CalTech)

- **Thanks to**

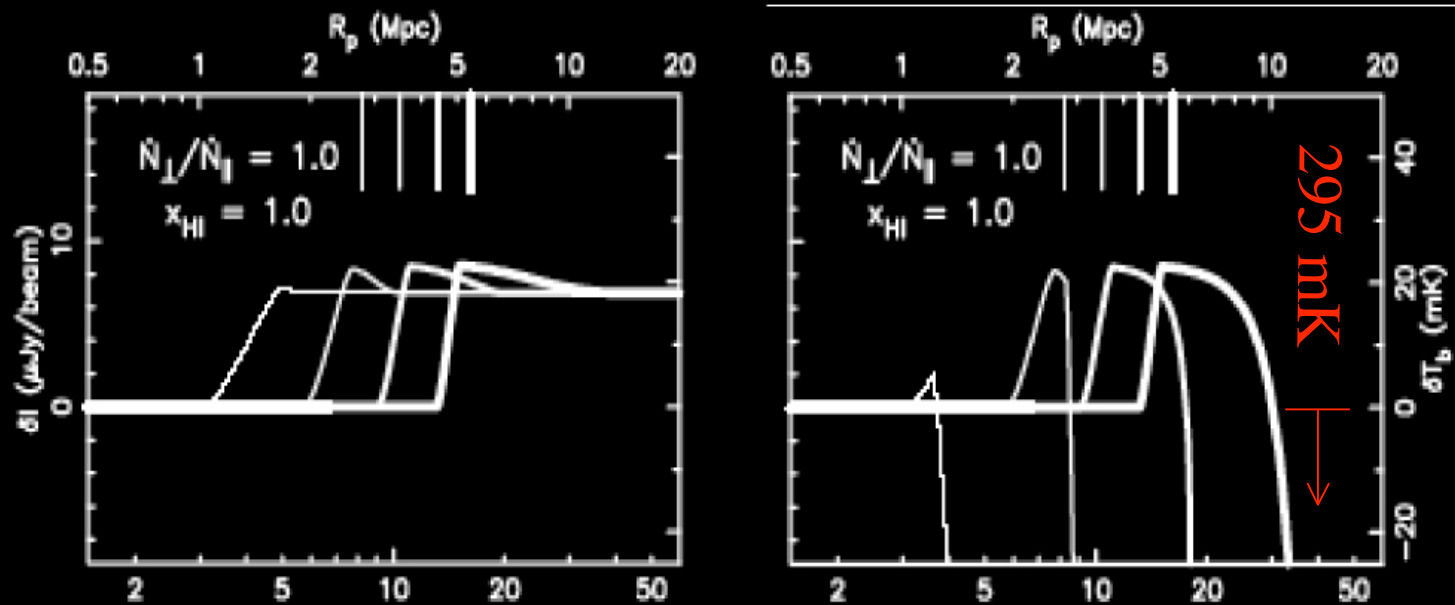
- R. Ridgeway, D. Mertely, W. Briskin, D. Frail,
B. Hicks

- Basic Goals
 - Detection of HI shells around “EOR quasars”
 - Exploration of line brightness fluctuations over $\sim 10^{(^\circ)^2}$
 - Explore noise-limited deep imaging
 - Befriend galactic foregrounds
- Status
 - Funding **approved** by Smithsonian (*October 1*)
 - US\$110K
 - Leverages previous investments in the VLA
 - Peer reviewed by NRAO
 - Technical/management review begins ... this week
- Proposed tracks in late **2005**, early **2007**.
- Permanent addition to VLA/EVLA $\Rightarrow$ Legacy science.

Strong Signal Case and (more likely) Weak Signal Case



How Strong is Strong - How Weak is Weak?



(Wyithe & Loeb)

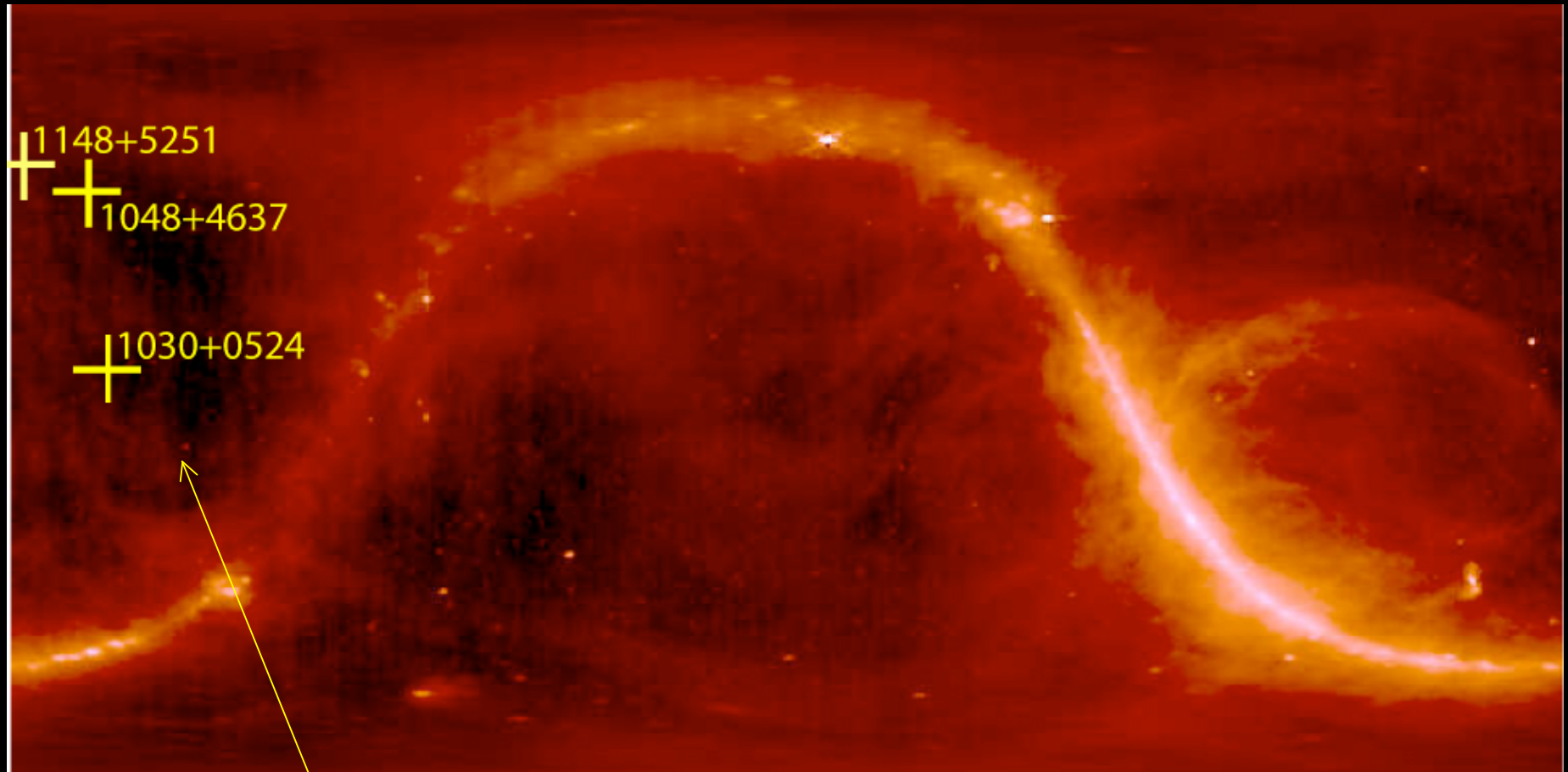
- Initial target list: 3 SDSS quasars ($z=6.2-6.4$) that show a “depth effect” to the Ly α absorption (Fan et al.).
- The HI lines will lie at 192-196 MHz.

Key VLA/VHF Science Questions

- What are the shapes/sizes of the HII regions?
 - How anisotropic is the ionizing radiation?
 - When did the quasars form after recombination?
- What is the nature of the IGM at $z \sim 6.3$?
 - Did T_{spin} exceed T_{CMB} ?
- What is the reionization history?
 - Constrain the neutral fraction at $z \sim 6.3$

Pathfinder program w/r to foreground elimination and assessment of gross signal strength (case A/B).

The Sky at 408 MHz

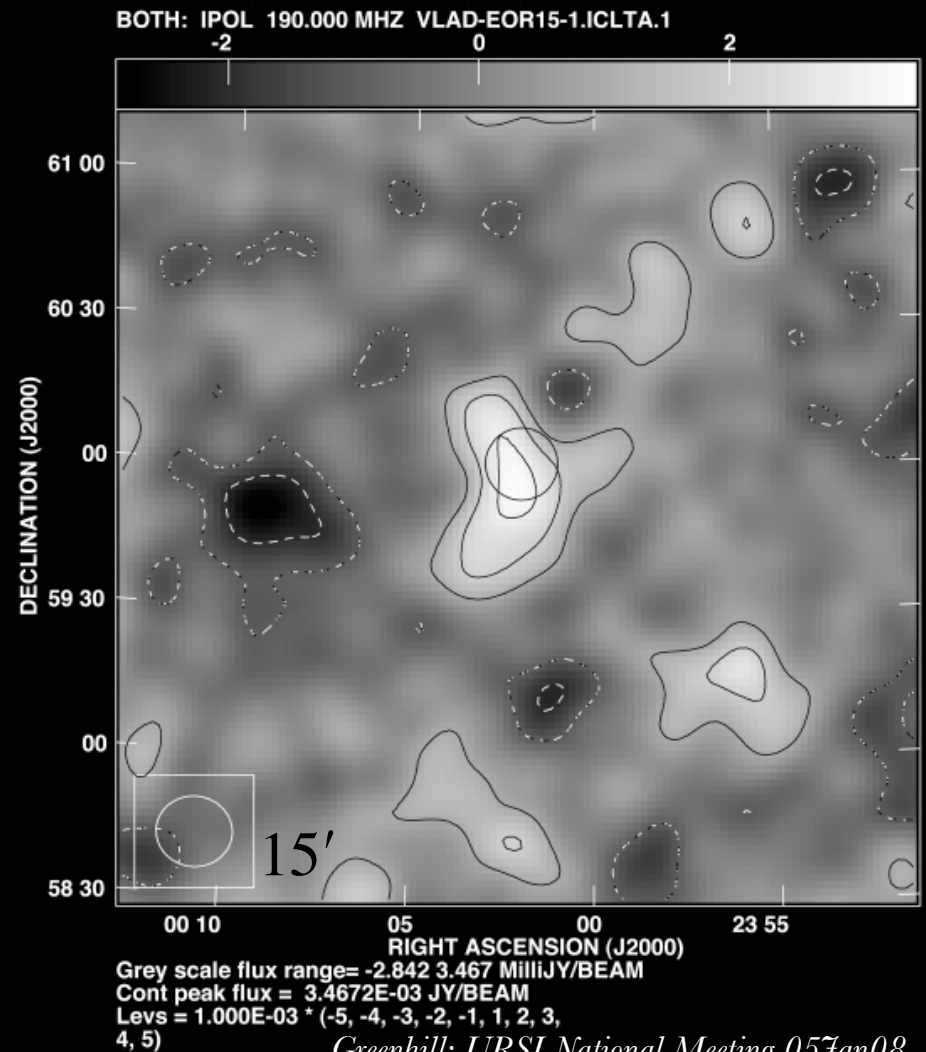
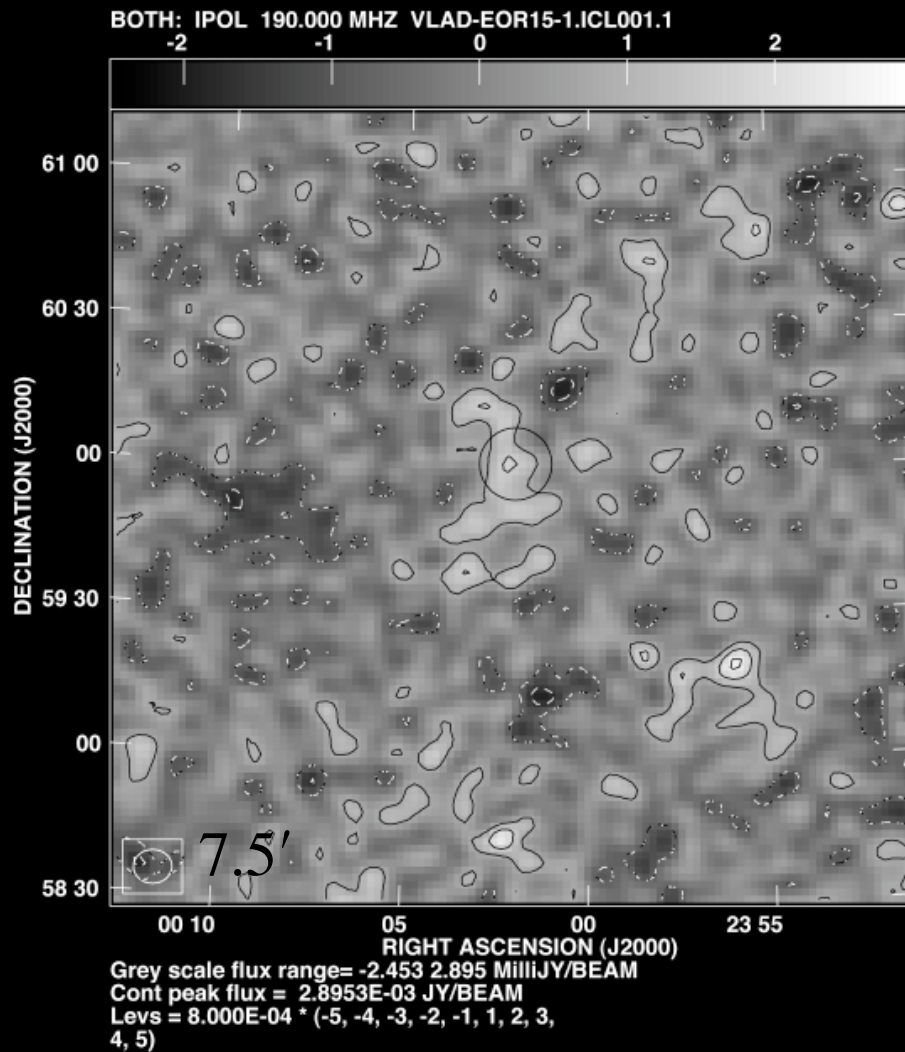


*Data from
Haslam et al. 1982*

$$T_{\text{sky}} = 14\text{-}16 \text{ K (408 MHz)} \Rightarrow \sim 110 \text{ K (194 MHz)}$$

Simulated VLA-D images

250^h - D-array - T_{sys}=180 - $\eta_e=0.4$ - 0.8 MHz - warm IGM - f(HI)=1



Greenhill: URSI National Meeting 057Jan08

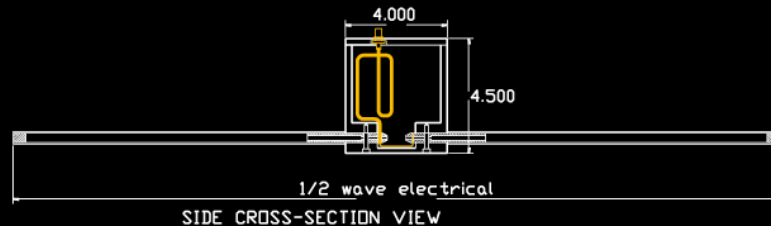
Placement of Proposed VHF Feeds



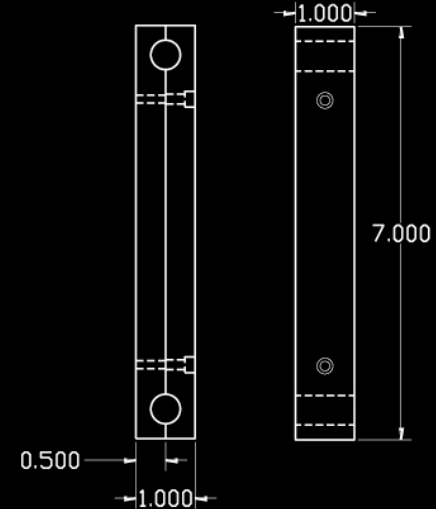
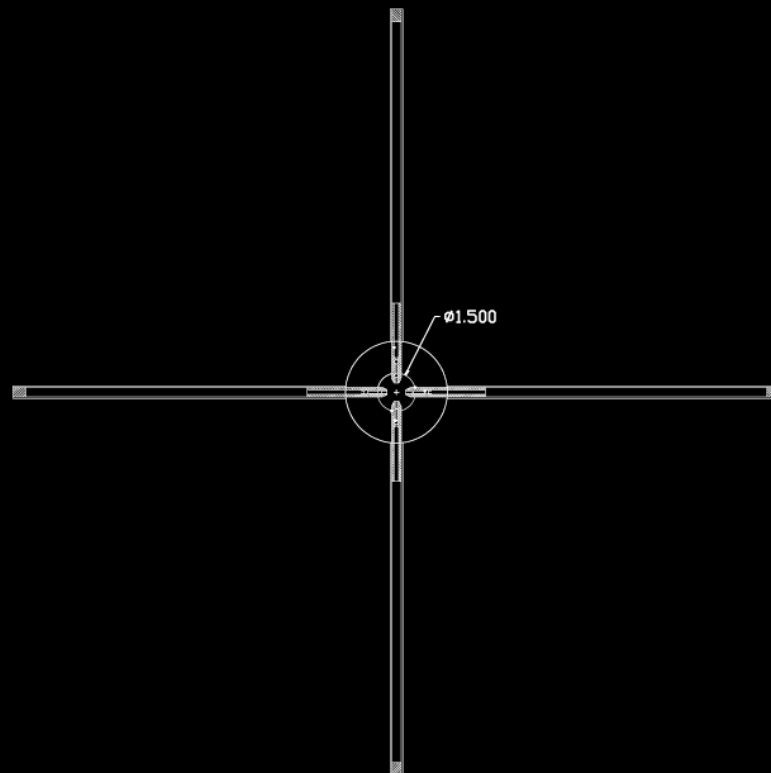
Although $A_e(327 \text{ MHz}) \sim 0.4$, $A_e(\text{VHF}) \sim 0.50$!

Greenhill: URSI National Meeting 05Jan08

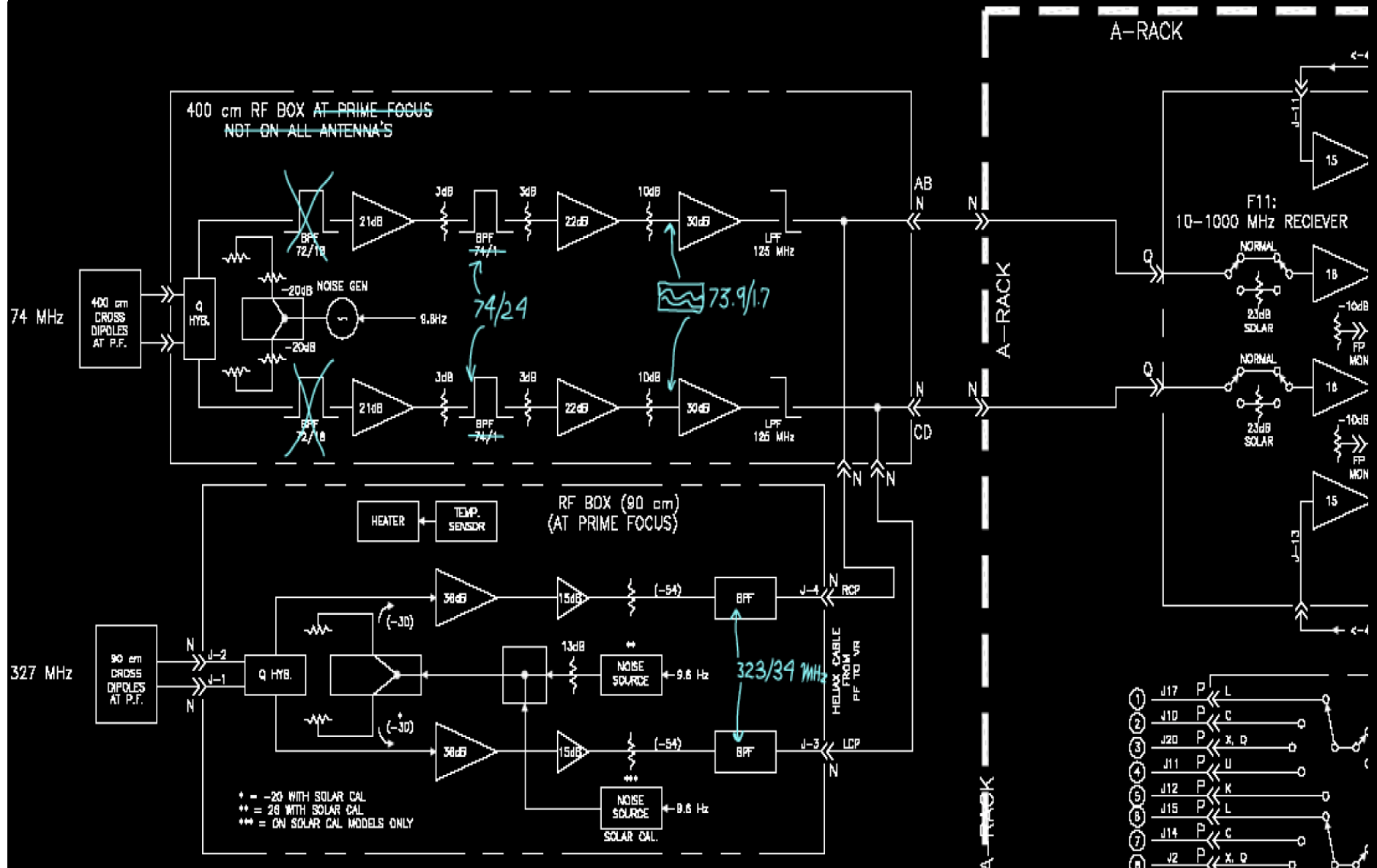
VHF Dipole Assembly



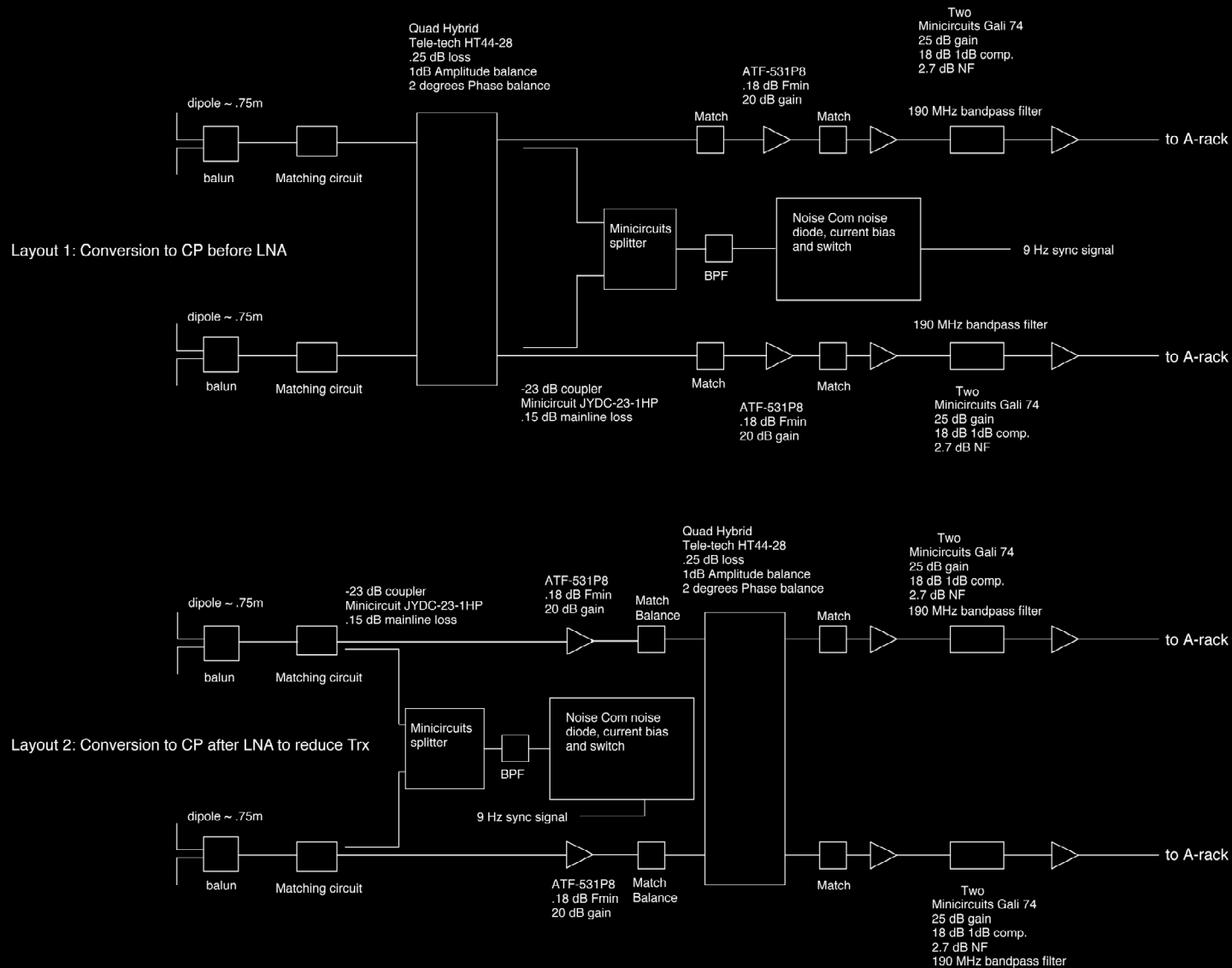
MATERIALS:
 DIPOLE ARMS ARE BRASS
 CENTRAL BODY IS MADE OF POLYETHYLENE TEREPHALATE



Current 4m and P-band RF electronics



VHF Rx Layouts



System Specifications

- Dipole - parabolic dish hybrid
 - Eases calibration
- Bandwidth - 178 - 208 MHz (1.6 m)
- Primary beam - $\sim 4^\circ$
- Synthesized beam - 5-15' (D-config.)
- $T_{\text{sys}} \sim 180 \text{ K}$
- $A_e \sim 0.5$ ($\sim 6600 \text{ m}^2$)
- Sensitivity $\sim 10 \text{ mK}$ in 50^h in 0.8 MHz
- Crossed dipole system
 - $\lambda/4$ from ground
 - $\sim \lambda/3$ from focus
- Invisibility

The VHF system design is optimized for sensitivity more so than existing 4m and P-band systems.

Table 1: VLA Low Frequency Systems

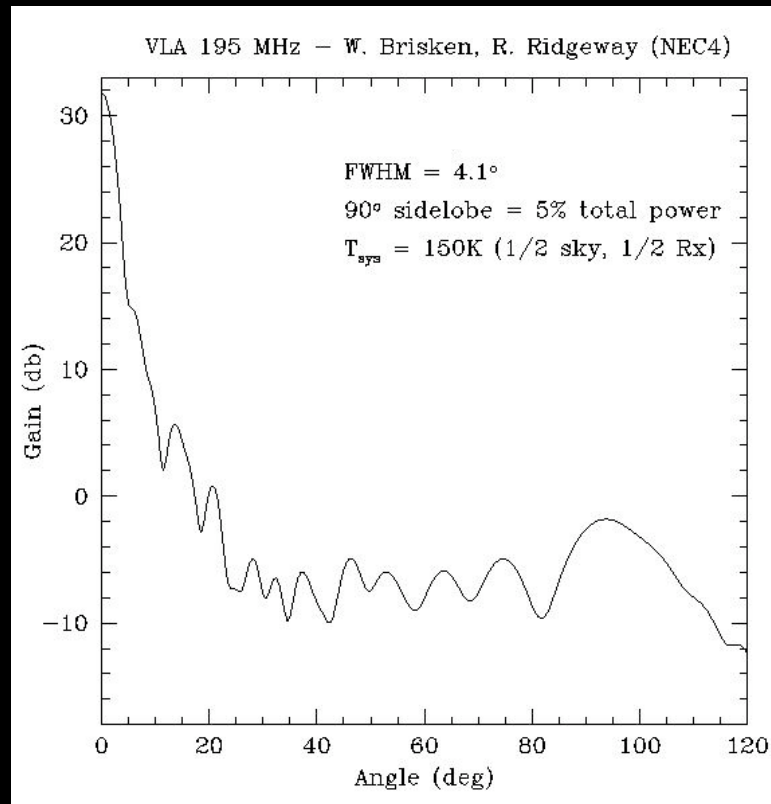
Band [MHz]	Passband [MHz]	$A_{\odot}$	T_{rx} [K]	T_{sky} [K]	D/λ	RMS(10min)* [mJy]	Δ/λ	Focus loss	FoV† [°]	(FoV/scaled rms) ^{2‡} [(°) ² mJy ⁻²]
74	73-74.5	0.15	...	10 ³	6	150	0.10	0.01	11	0.0054
VHF‡	178-202	0.5	60¶	100	16	0.9	0.27	0.08	4.1	3
320	305-337	0.4	100¶	25	27	1.4	0.43	0.24	2.5	0.17
1400	1240-1700	0.55	30	3	125	0.056	...	...	0.50	0.22

The VLA antennas are complex structures. In the VHF band, deployment of a prototype Rx is critical to validation of expected antenna performance



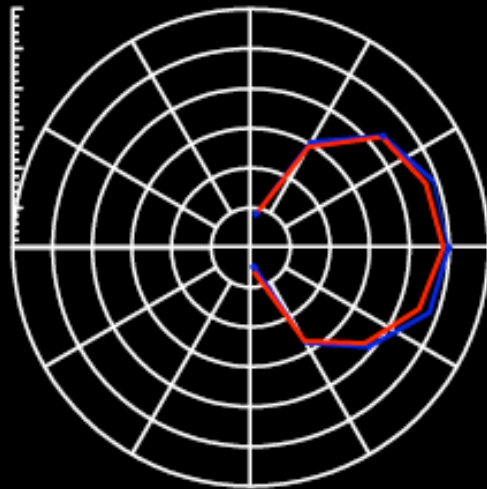
$$A_e(\text{VHF}) \sim 0.50 ?$$

Beam Response from Partial E&M Model



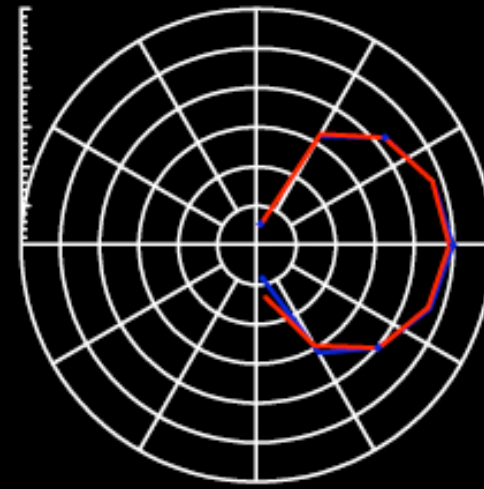
194-320 MHz Dipole Interaction

P-band Feed Response at 300MHz

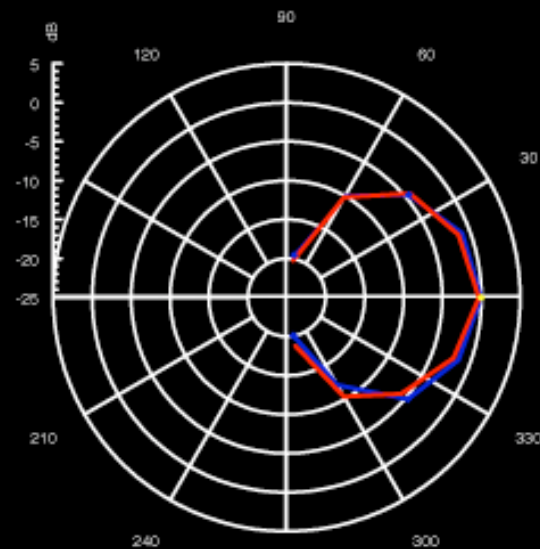


$\Delta(0^\circ)=0.7$ dB

P-band Feed Response at 327MHz

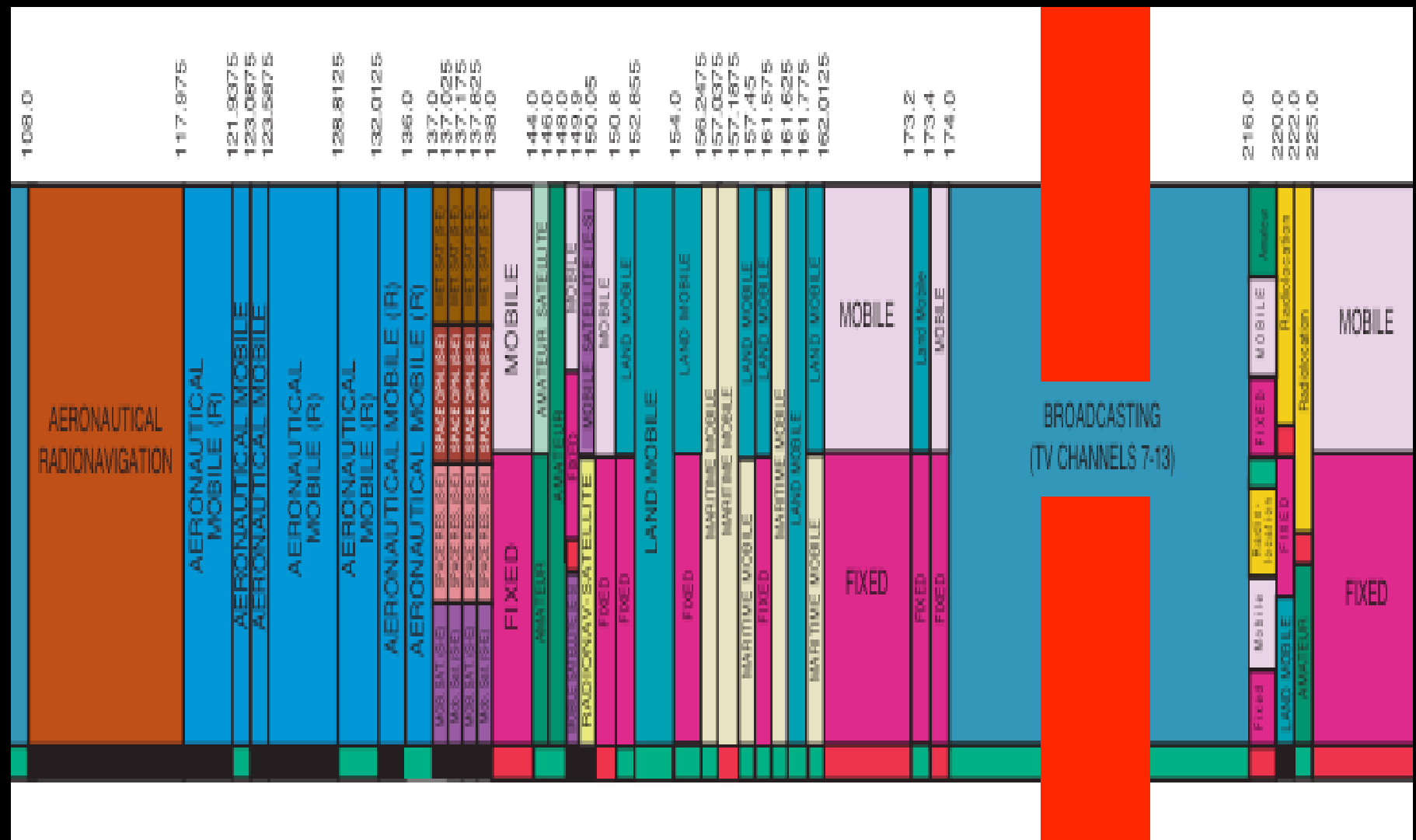


$\Delta(0^\circ)=0.5$ dB



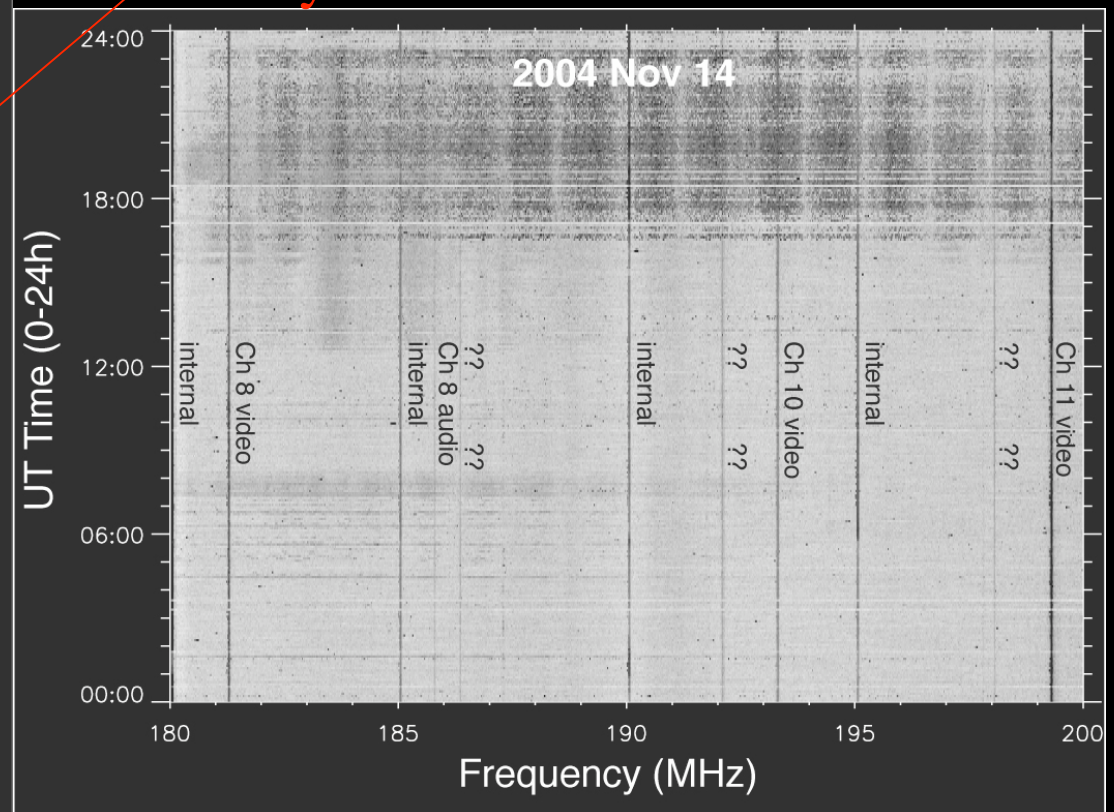
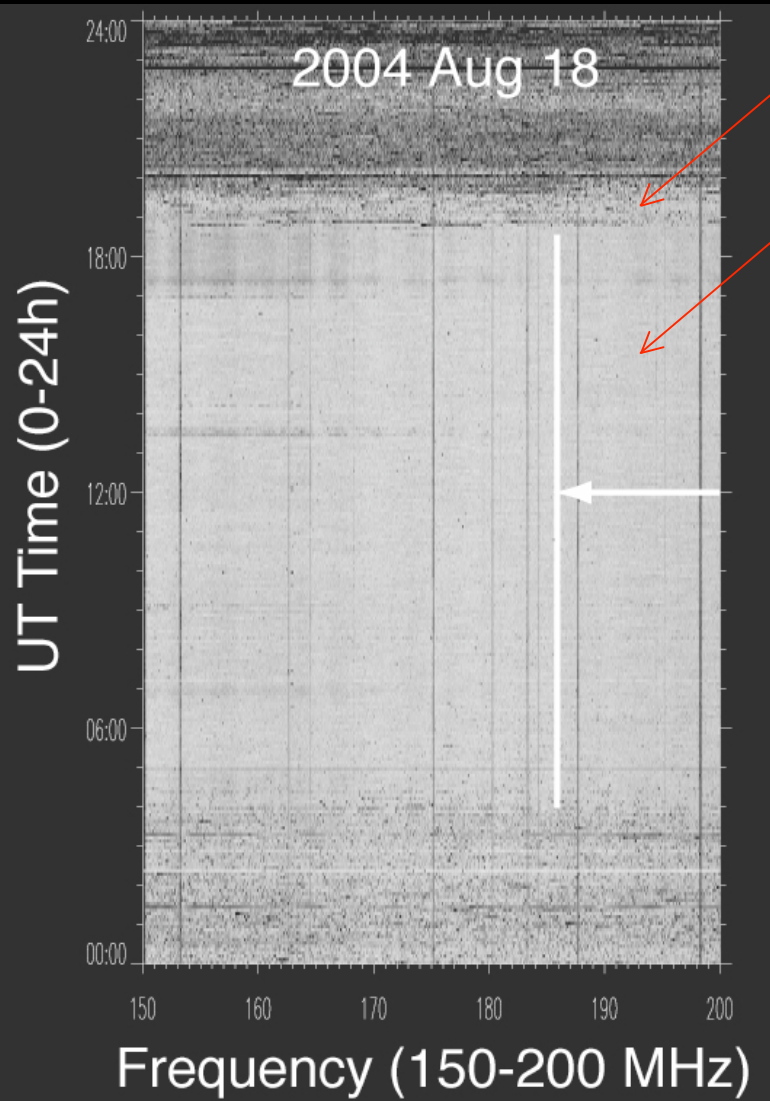
$\Delta(0^\circ)=0.3$ dB

Radio Spectrum Allocation



VHF RFI @ the VLA (2004)

Lightning
“Clear”
sky



Timeline

- Oct 1 '04 - SAO funding approved
Observing proposal
- Jan 5 '05 - Technical & Management report
- Feb 1 '05 - First prototype receiver delivered
- Feb 22 '05 - First report on RFI and performance
Go/no-Go
- Mar 8 '05 - 3 additional prototypes delivered
- Apr 15 '05 - Final report on performance
Begin h/w production
- Jun 1 '05 - “Large” observing proposal for 2007.
- Oct 27 '05 - D config first science observing