

# Optimized Small-Station EME

**X-pol at 432 MHz**

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# Motivation and Goals

- EME at W2PU (Princeton U ARC)
- Small antenna, modest cost
- Easy to build
- No “QRO++”
- → “Practical EME for any QTH”
- Can work its twin by EME, any time

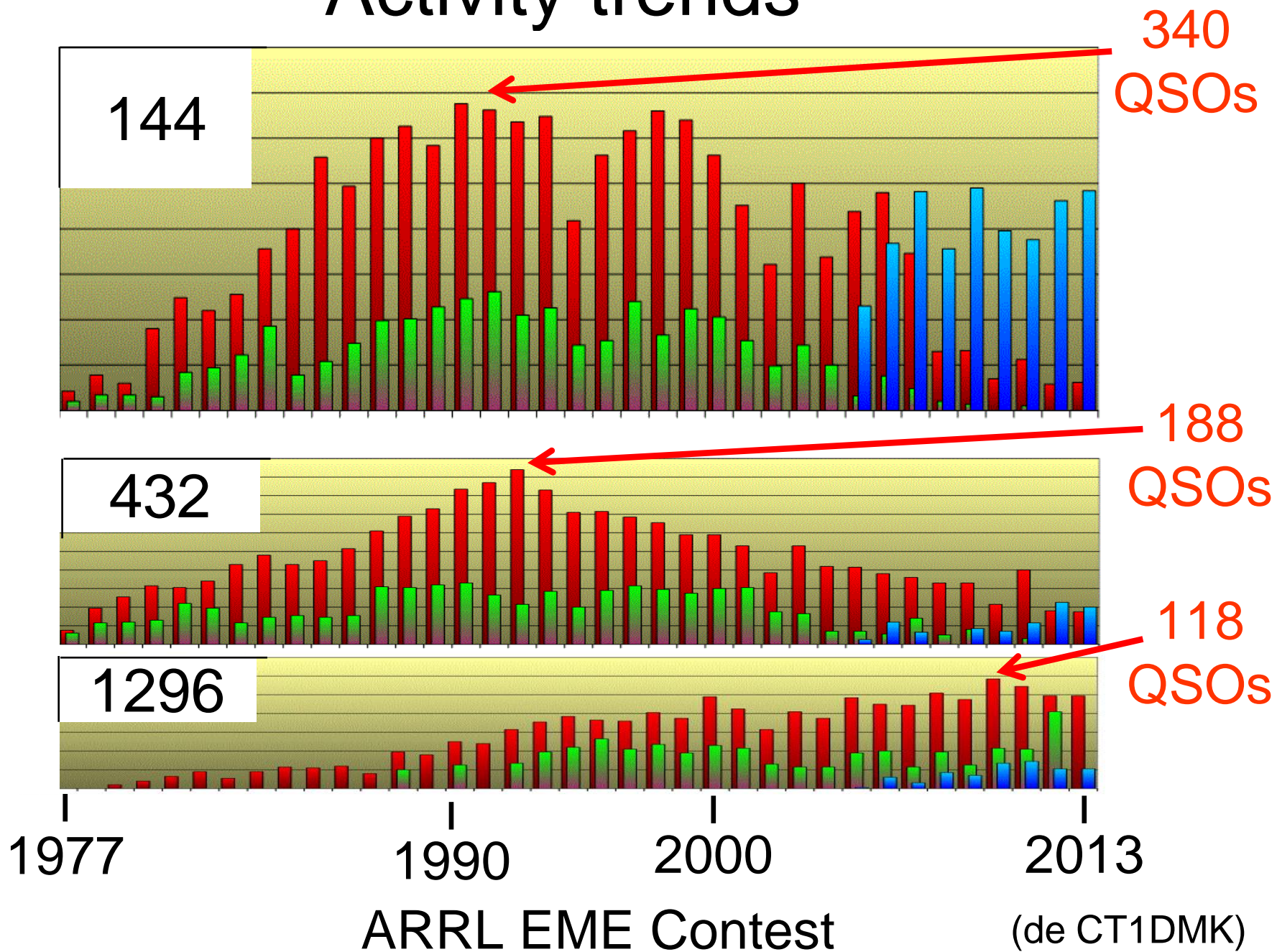
# Which Band ? 144 MHz ??

- Highest activity level
- Relatively simple equipment
- X-pol is very effective
- 4 yagis are enough
- Feedline losses are low
- High  $T_{\text{sky}}$
- Antennas are BIG !

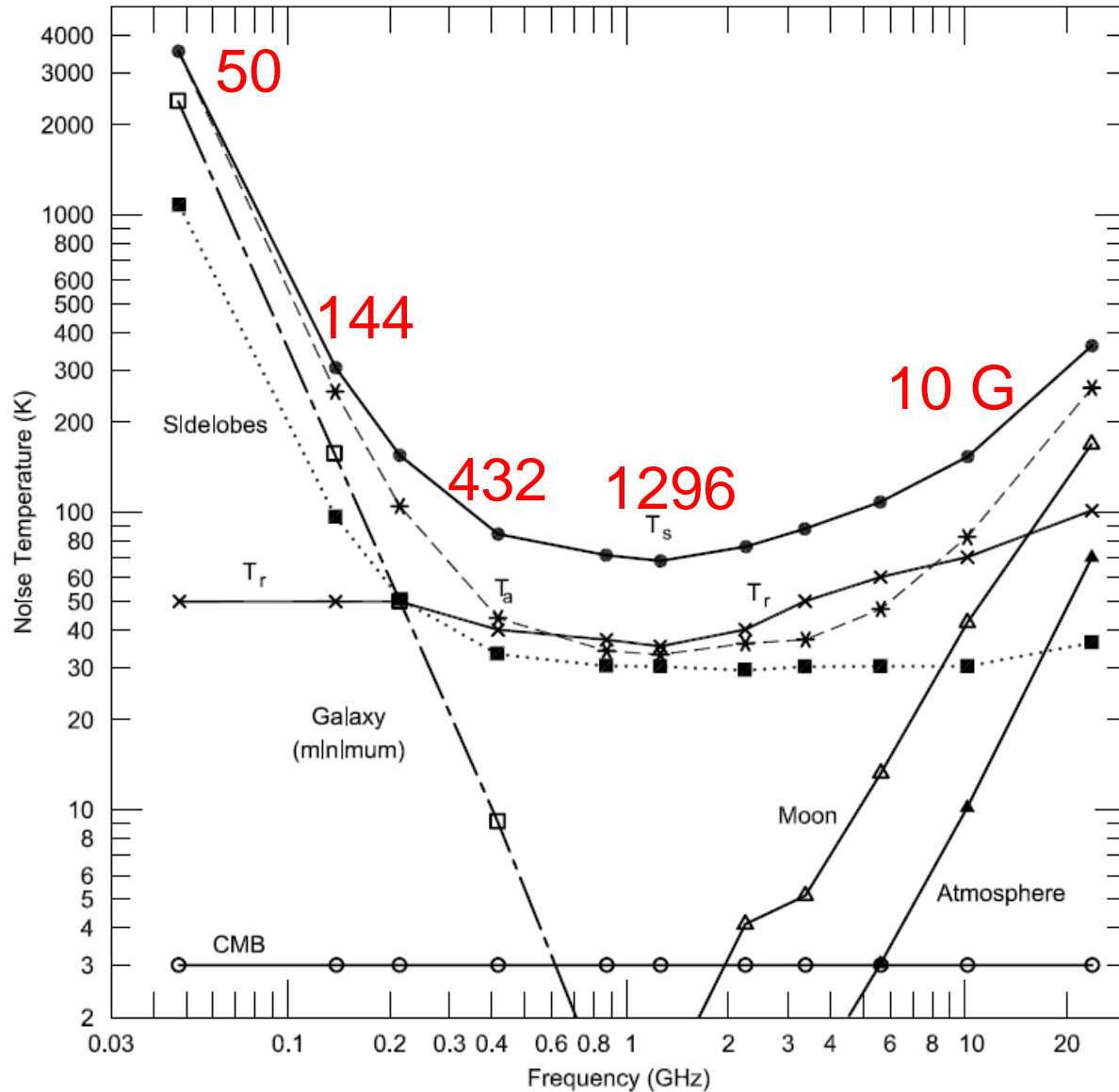
# Which Band ? 1296 MHz ??

- Second highest activity level
- Very low  $T_{\text{sky}}$
- Circular pol – very convenient !
- Dish antennas,  $d \geq 2$  m
- Problems for QTHs with tall trees

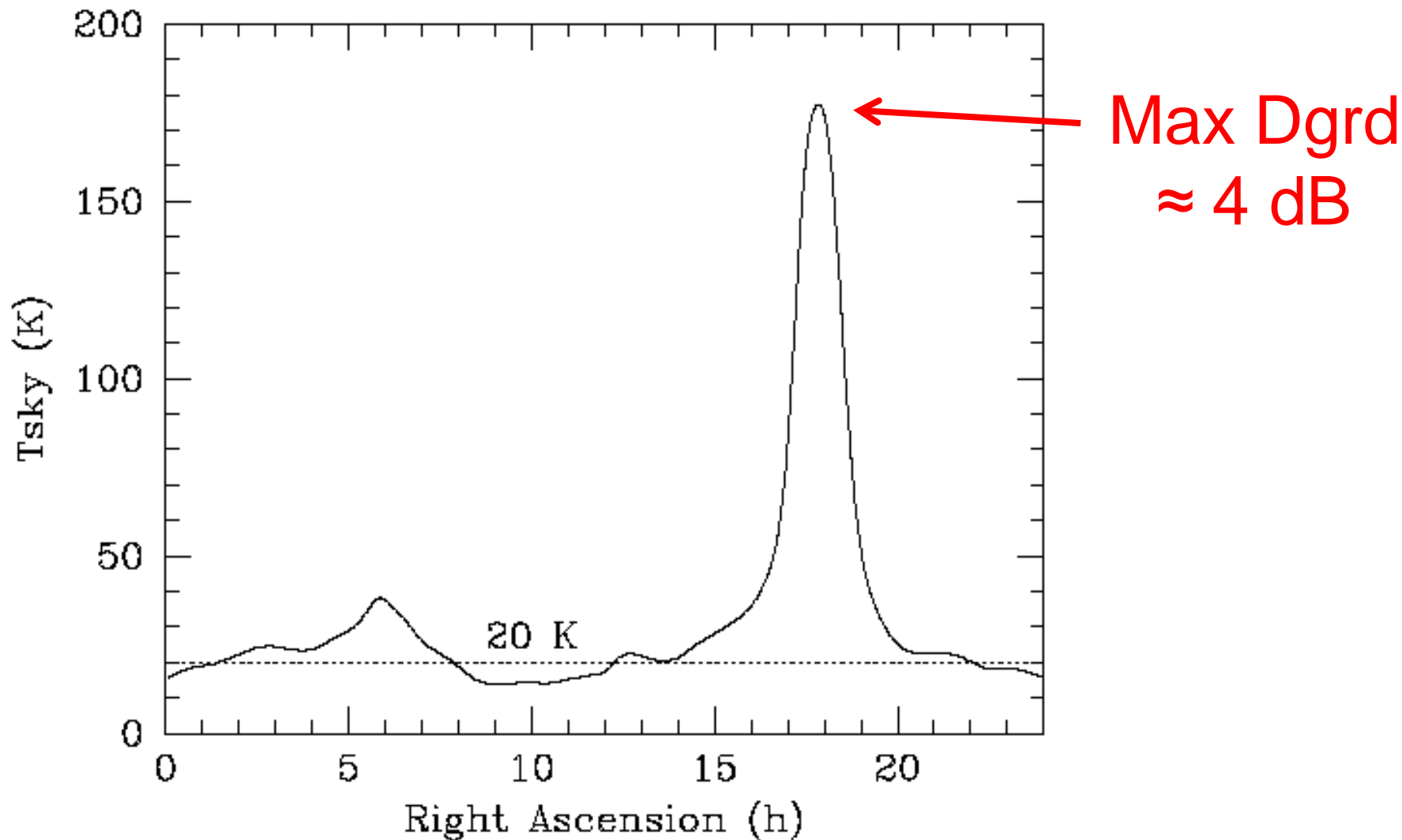
# Activity trends



# Achievable $T_{\text{sys}}$ vs Frequency



# $T_{\text{sky}}$ on the Ecliptic, 432 MHz (Beamwidth = $15^\circ$ )



# So: We Chose 432 MHz

- Equipment similar to 2m
- Plenty of off-the-shelf equipment
- Low  $T_{\text{sky}}$
- Antennas *much* smaller than 2 m
- DXpedition- and neighbor-friendly
- X-pol highly desirable (but difficult?)
- The most under-utilized EME band !
- So... Where is everybody ?



# Antenna Gain to work our “Twin”

$$SNR = P_t + G_t + G_r - L - P_n$$

$$L = 261.5 \quad \text{dB}$$

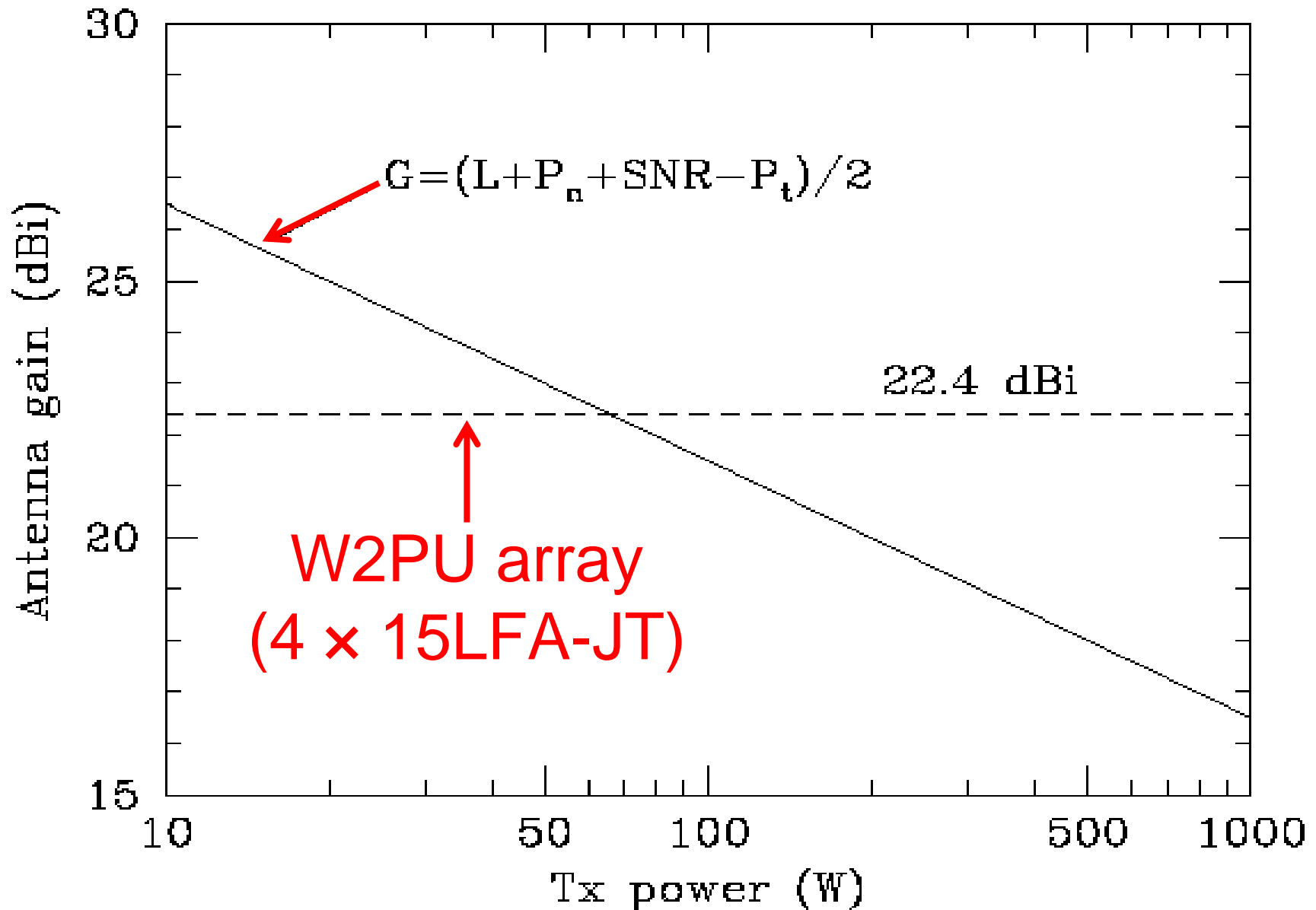
$$P_n = 10 \log(kTB) = -174.6 \quad \text{dBW}$$

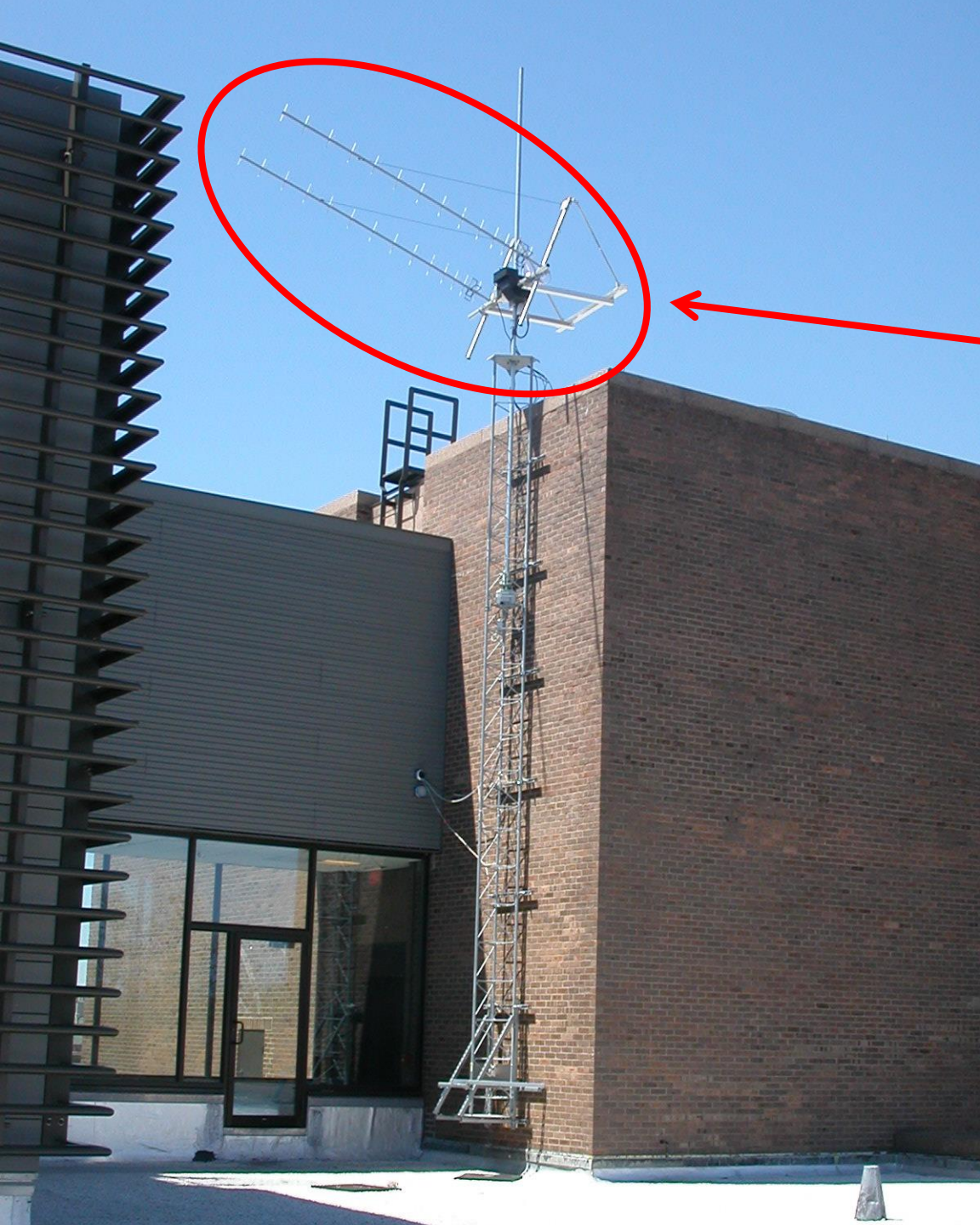
$$(T = 100 \text{ K}, B = 2500 \text{ Hz})$$

**Solve for  $G$ , set  $SNR = -24 \text{ dB}$ :**

$$\begin{aligned} G &= (G_t + G_r)/2 = (L + P_n + SNR - P_t)/2 \\ &= 31.5 - P_t/2 \quad \text{dBi} \end{aligned}$$

# Antenna Gain to work our "Twin"





First: Build and  
test two yagis  
(Summer 2013)

2 × 15LFA-JT  
X-pol Yagis





**2 x 15LFA-JT**  
**19.4 dBi**



# Yagi Design (G0KSC)

- Careful mechanical design
- Rear mounted
- Hollow fiberglass boom, 25×25 mm, 3.5 m
- Driven loops: 10 mm brass tubing
- Parasitic elements: ¼ inch aluminum rod
- Guys: 1/8 inch Dacron rope
- $Z = 50 \Omega$
- Return loss > 25 dB, 427 to 437 MHz

# Array Design

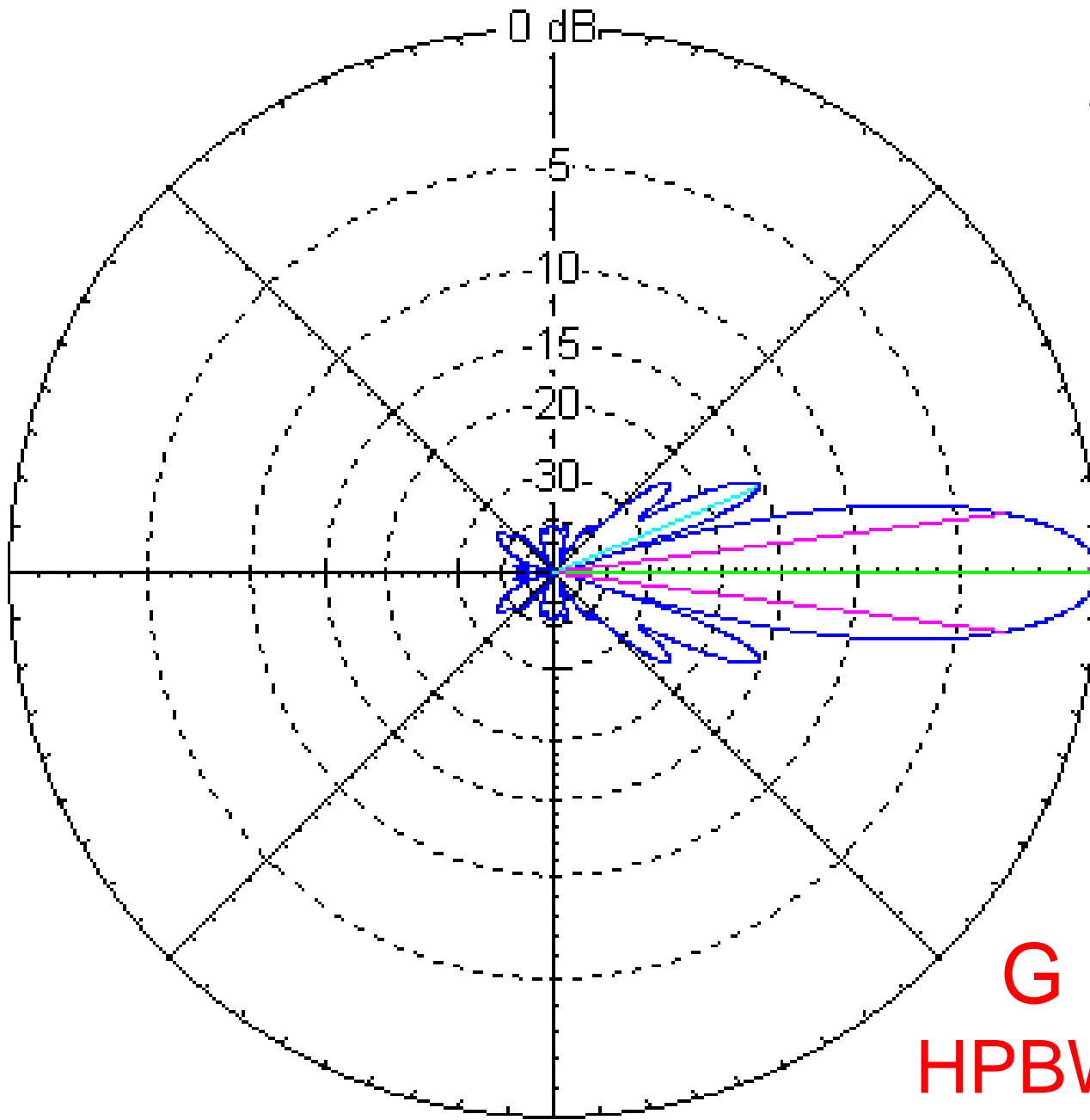
- Stacking distance  $1.2 \times 1.2$  m
- Feedline exit through rear of boom
- RG-142 from loops to splitters
- Power splitters:  $1.5 \lambda$
- Overall size and weight: less than an HF tri-bander !









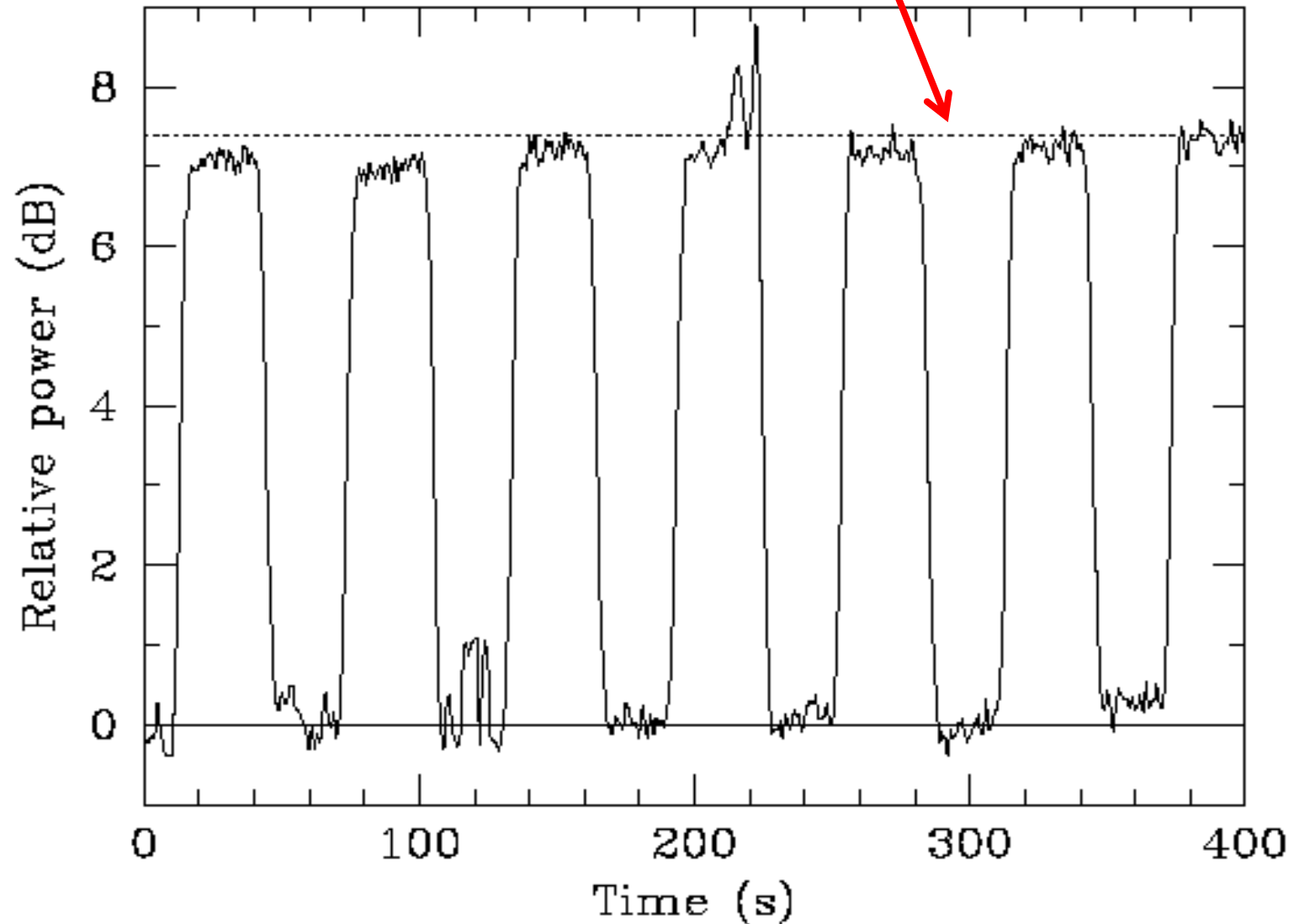


**2 × 15LFA-JT**

**Calculated  
pattern  
(G0KSC)**

**$G = 19.4 \text{ dBi}$   
 $\text{HPBW (Az)} = 14.6^\circ$**

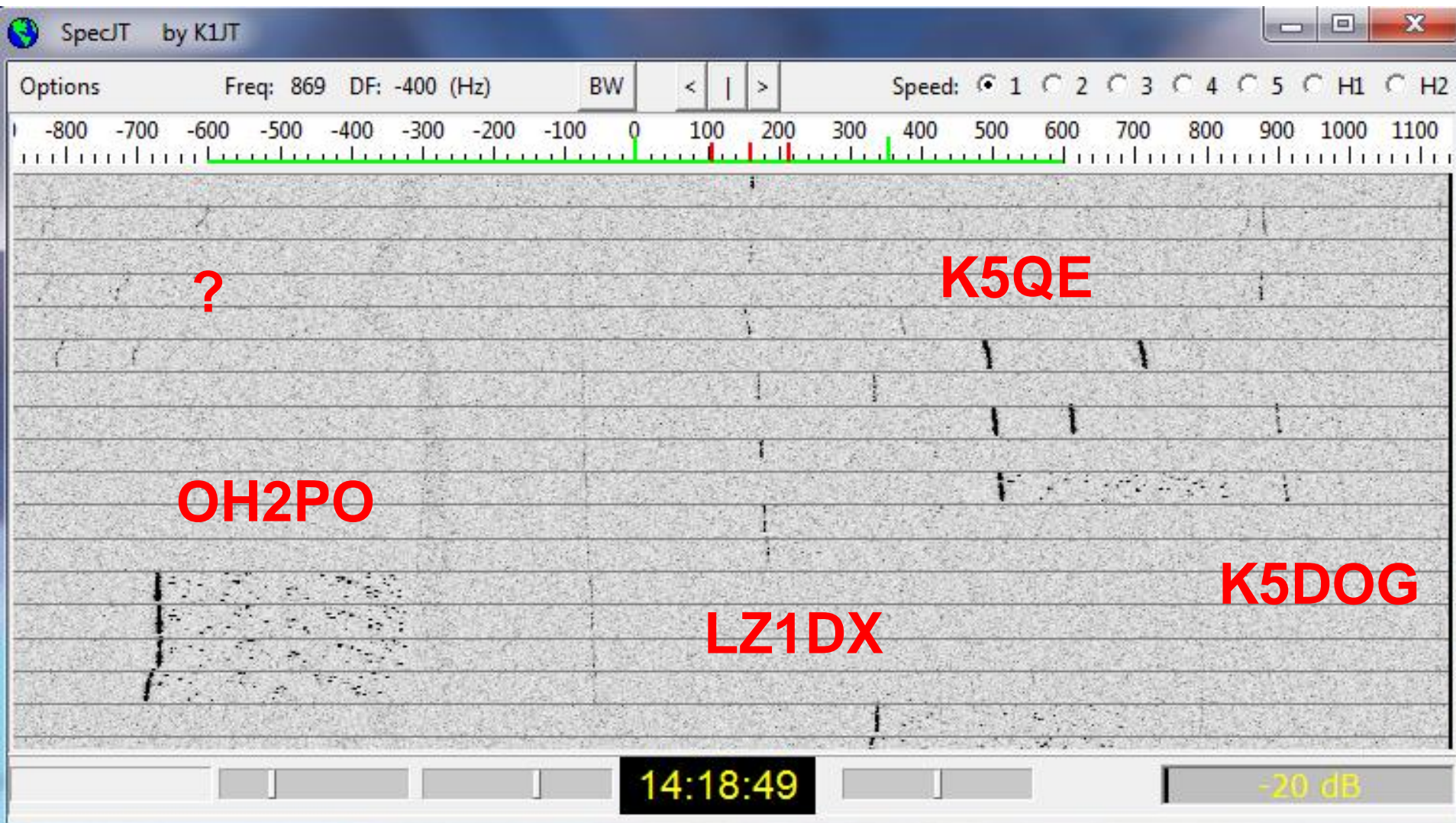
# Measured Sun Noise: 2 × 15LFA-JT (Predicted $Y_{\text{sun}} = 7.4$ dB)





# EME signals at W2PU

November 2013 – 2 × 15LFA-JT





Present Setup  
4 × 15LFA-JT  
 $G = 22.4$  dBi



# Detailed Contributions to $T_r$

| Component        | Gain (dB) | NF (dB) | Contribution (K) |
|------------------|-----------|---------|------------------|
| 4 ft RG-142      | -0.32     |         | 22.2             |
| Power splitter   | -0.05     |         | 3.6              |
| 3 ft LDF 4-50A   | -0.04     |         | 2.9              |
| T/R relay        | -0.05     |         | 3.7              |
| LNA 1            | 23.0      | 0.4     | 30.8             |
| 75 ft LMR-240    | -3.74     |         | 2.3              |
| LNA 2            | 20.0      | 0.5     | 0.5              |
| IQ+              |           | 9       | 0.4              |
| <b>Total (K)</b> |           |         | <b>66.4</b>      |

Every  
detail  
counts!

| Tsys Worksheet                     | Gain         | Noise Figure | Noise Contribution |         |
|------------------------------------|--------------|--------------|--------------------|---------|
|                                    | (dB)         | (dB)         | (K)                | % Total |
| 4 ft RG-142                        | -0.32        |              | 22.2               | 18.7%   |
| Power splitter                     | -0.05        |              | 3.6                | 3.1%    |
| 3 ft LDF 4-50A                     | -0.04        |              | 2.9                | 2.5%    |
| T/R relay                          | -0.05        |              | 3.7                | 3.1%    |
| LNA1 (DB6NT)                       | 23.00        | 0.40         | 30.8               | 26.0%   |
| 10 ft LMR400                       | -0.27        |              | 0.1                | 0.1%    |
| 100 ft LMR240                      | -5.20        |              | 3.9                | 3.3%    |
| 10 ft RG58                         | -1.00        |              | 1.5                | 1.2%    |
| LNA2 (ARR)                         | 20.00        | 0.50         | 0.9                | 0.7%    |
| LinkRF IQ+                         |              | 9.00         | 0.5                | 0.4%    |
| Tr at antenna feedpoint            |              | <b>0.94</b>  | <b>70.0</b>        | 59.2%   |
| Antenna and feed losses            | 0.06         |              | 4.0                | 3.4%    |
| Sky noise (main beam, on ecliptic) |              |              | 20.0               | 16.9%   |
| Side and rear lobes                |              |              | 25.0               | 21.1%   |
| Total antenna noise, Ta            |              |              | 48.4               | 40.8%   |
| System noise temperature, Ts       |              |              | <b>118.4</b>       | 100.0%  |
| Frequency (MHz)                    | 432          |              |                    |         |
| Lossless antenna gain (dBi)        | 22.40        |              |                    |         |
| Solar Flux at 432 MHz (SFU)        | 44.0         |              |                    |         |
| Tx power at antenna (W)            | 100          |              |                    |         |
| EME path loss (dB)                 | 261.6        |              |                    |         |
| G/Ta (dB/K)                        | 5.5          |              |                    |         |
| G/Ts (dB/K)                        | <b>1.6</b>   |              |                    |         |
| Y Sun (dB)                         | <b>9.9</b>   |              |                    |         |
| EME S/N in B=2500 Hz (dB)          | <b>-23.0</b> |              |                    |         |
| EME S/N in B=50 Hz (dB)            | <b>-6.0</b>  |              |                    |         |

$T_r$

$T_a$

Bottom line:

$$T_{\text{sys}} = 118 \text{ K}$$

$$Y_{\text{sun}} = 9.9 \text{ dB}$$

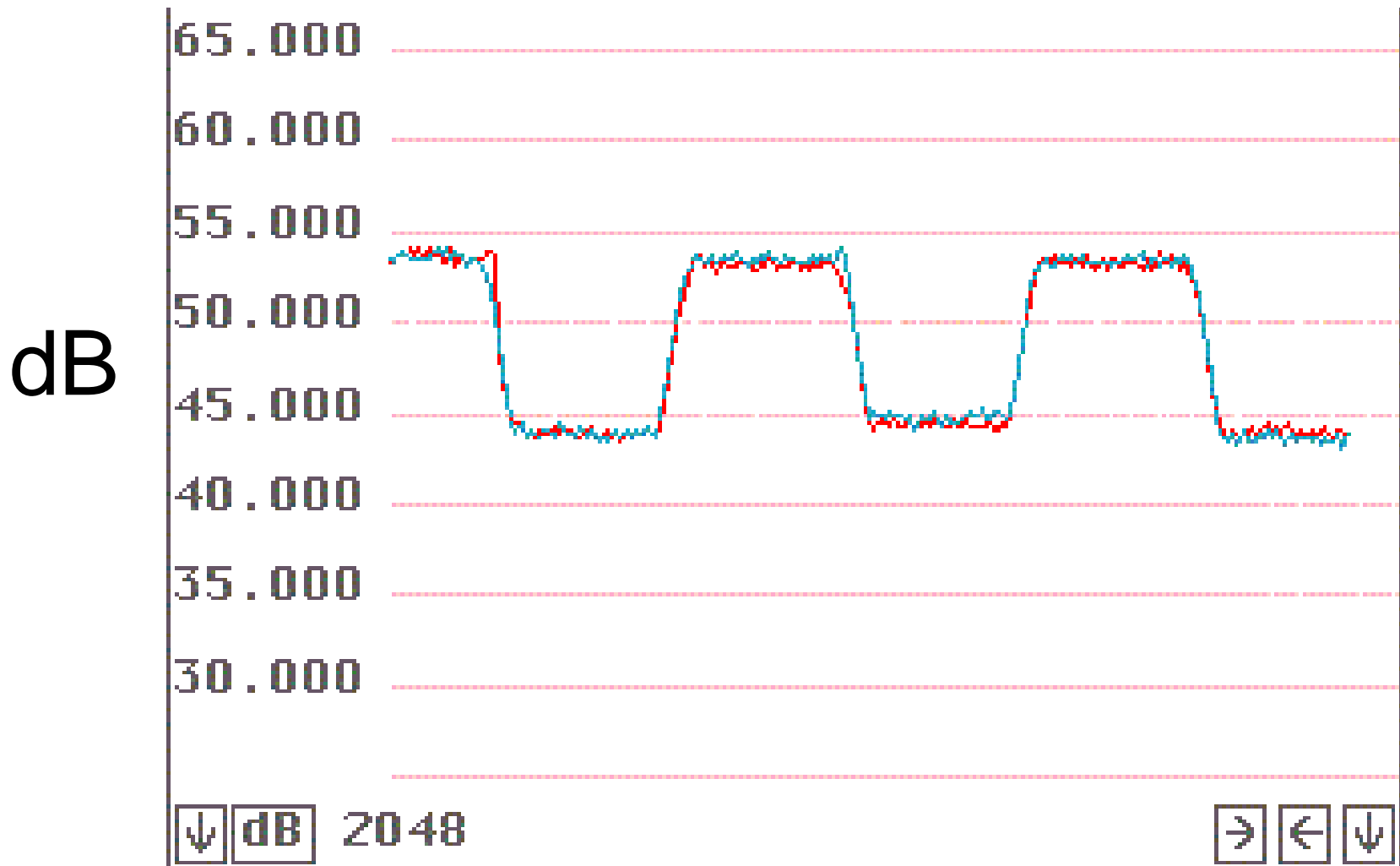
$$P = 100 \text{ W}$$

$$S/N = -23 \text{ dB}$$

Spreadsheet available online

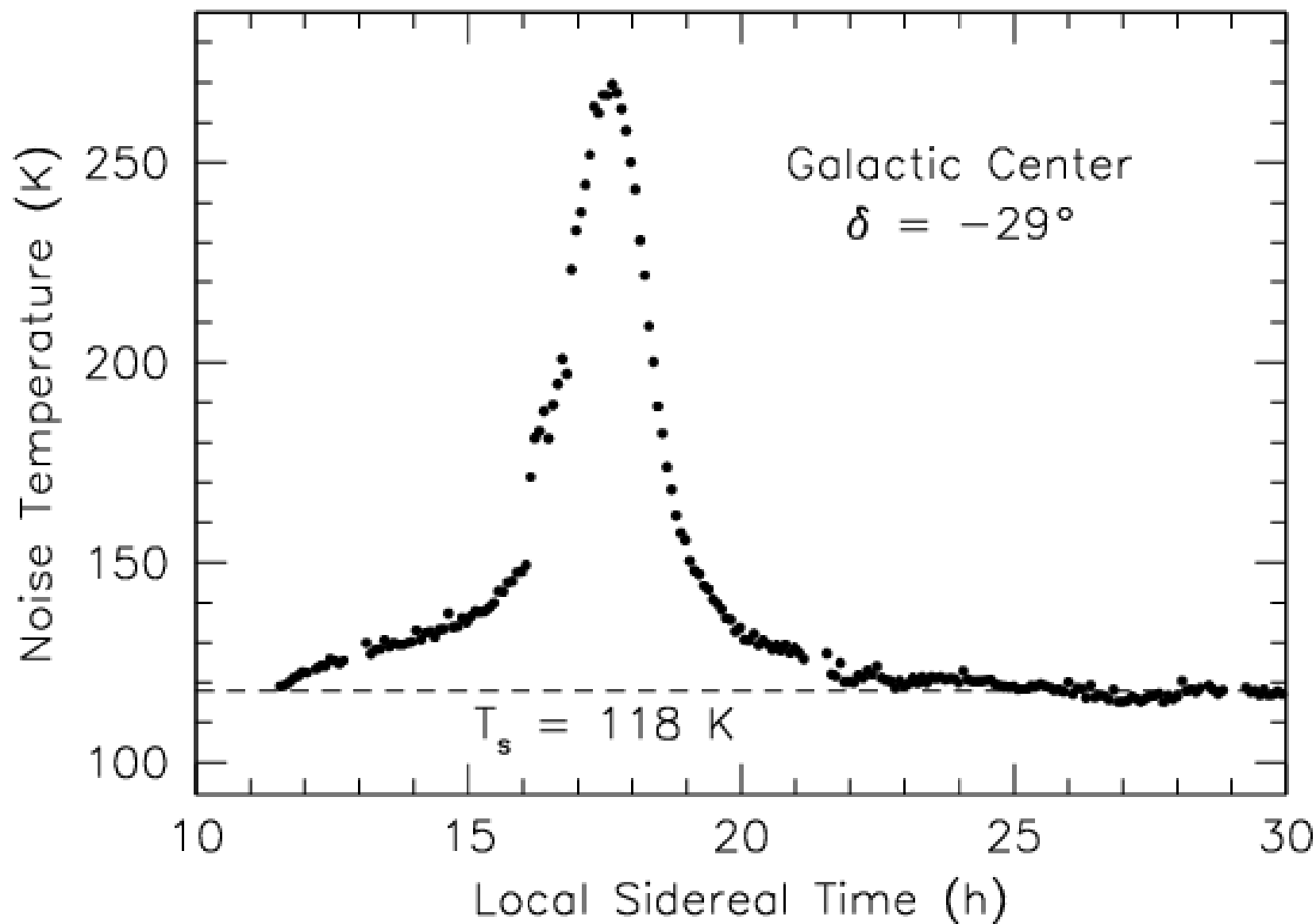
# Sun Noise using Linrad S-meter

4 × 15LFA-JT: Predicted  $Y_{\text{sun}} = 9.9 \text{ dB}$





# Drift curve of galactic center



# W2PU Echo-mode “selfie”

-19 dB →

The screenshot shows the WSJT 10.0 software interface. At the top, the title bar reads "WSJT 10.0 r4227 by K1JT". The menu bar includes "File", "Setup", "View", "Mode", "Decode", "Save", "Band", and "Help".

The main display area features a spectrum plot with a prominent red peak. To the right of the plot, a cyan box displays the following data:

**Moon**  
Az: 259.94  
El: 20.03  
Dop: -1089  
Dgrd: -0.9

Below the plot is a table of detected signals. The table has columns for N, Level, Sig, DF, Width, Az, El, and Q. A red box highlights the "29" in the first row and "DF (Hz)" in the header.

| N | Level | Sig   | DF   | Width | Az    | El   | Q  |
|---|-------|-------|------|-------|-------|------|----|
| 2 | 7.5   | -22.2 | -0.7 | 1.0   | 259.8 | 20.2 | 4  |
| 3 | 6.1   | -21.7 | -0.7 | 0.7   | 259.8 | 20.2 | 5  |
| 4 | 6.2   | -19.0 | -0.7 | 0.3   | 259.8 | 20.1 | 10 |
| 5 | 6.3   | -19.9 | -0.7 | 0.3   | 259.9 | 20.1 | 10 |
| 6 | 6.2   | -19.1 | -0.7 | 0.3   | 259.9 | 20.1 | 10 |
| 7 | 6.2   | -19.4 | -0.7 | 0.3   | 259.9 | 20.1 | 10 |
| 8 | 6.1   | -19.6 | -0.7 | 0.3   | 259.9 | 20.1 | 10 |
| 9 | 6.1   | -19.1 | -0.7 | 0.3   | 259.9 | 20.1 | 10 |

Below the table is a control bar with buttons: "Log QSO", "Stop", "Monitor" (highlighted in green), "Decode", "Erase", "Clear Avg", "Include", "Exclude", and "Tx Stop".

The bottom section contains fields for "To radio: VK3NX", "Grid: QF21", and "Hot A: 269". A red box highlights "Auto is ON". A large black box displays the date and time: "2014 Aug 14 12:48:59".

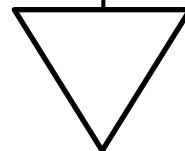
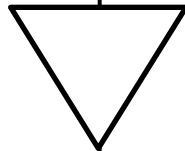
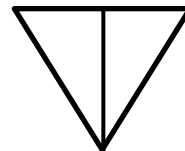
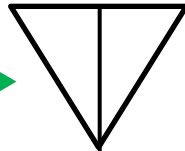
The status bar at the bottom shows "1.0000 1.0000", "Echo", "Freeze DF: 993", "Rx noise: -2 dB", "T/R Period: 6 s", and a green "Receiving" button.

**W2PU**

**4 × 15LFA-JT** →

**H**

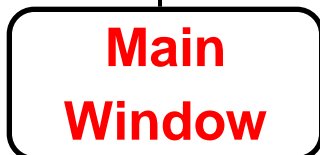
**V**



↑  
**Hardware**



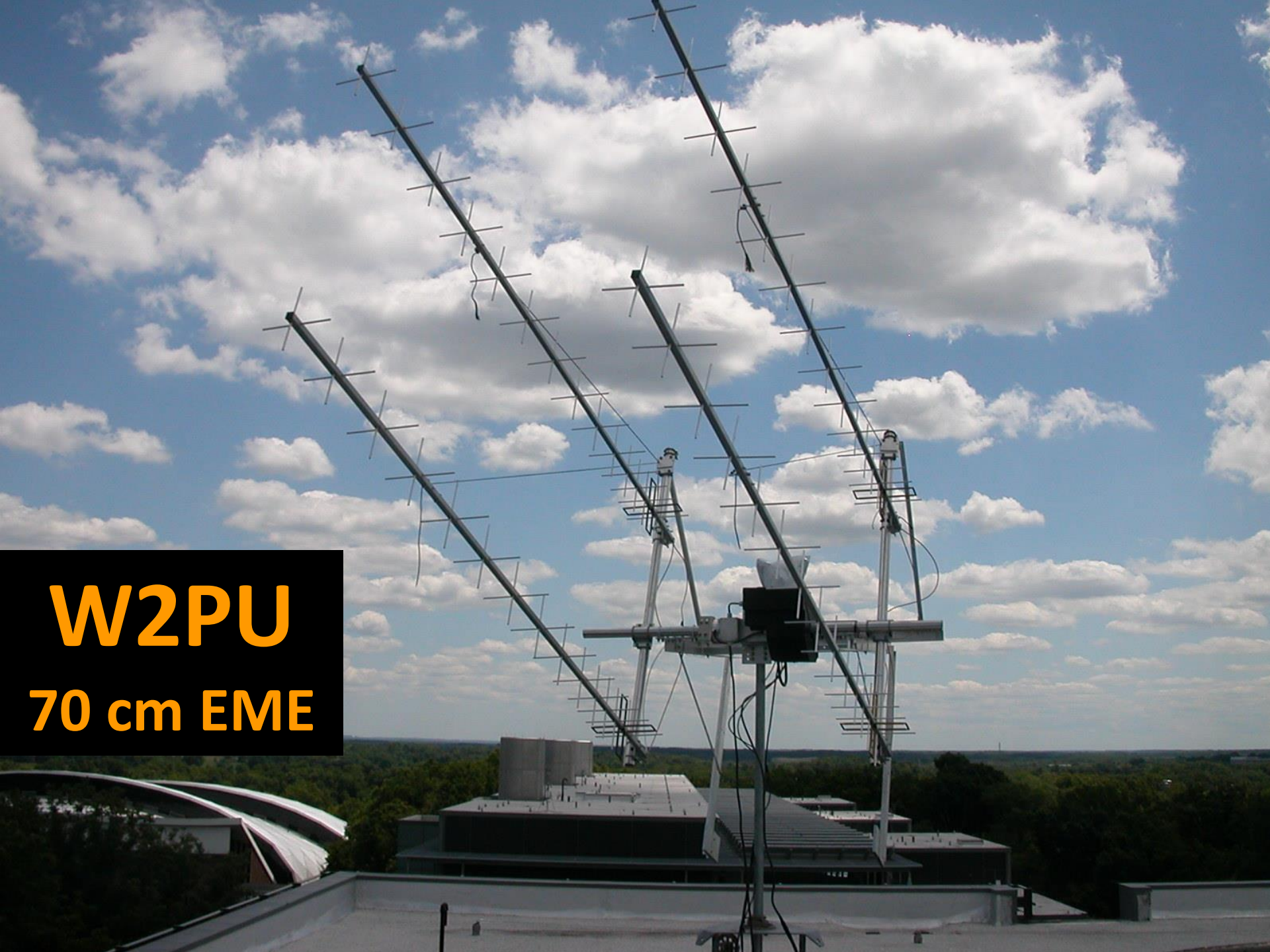
-----  
**Software**  
↓



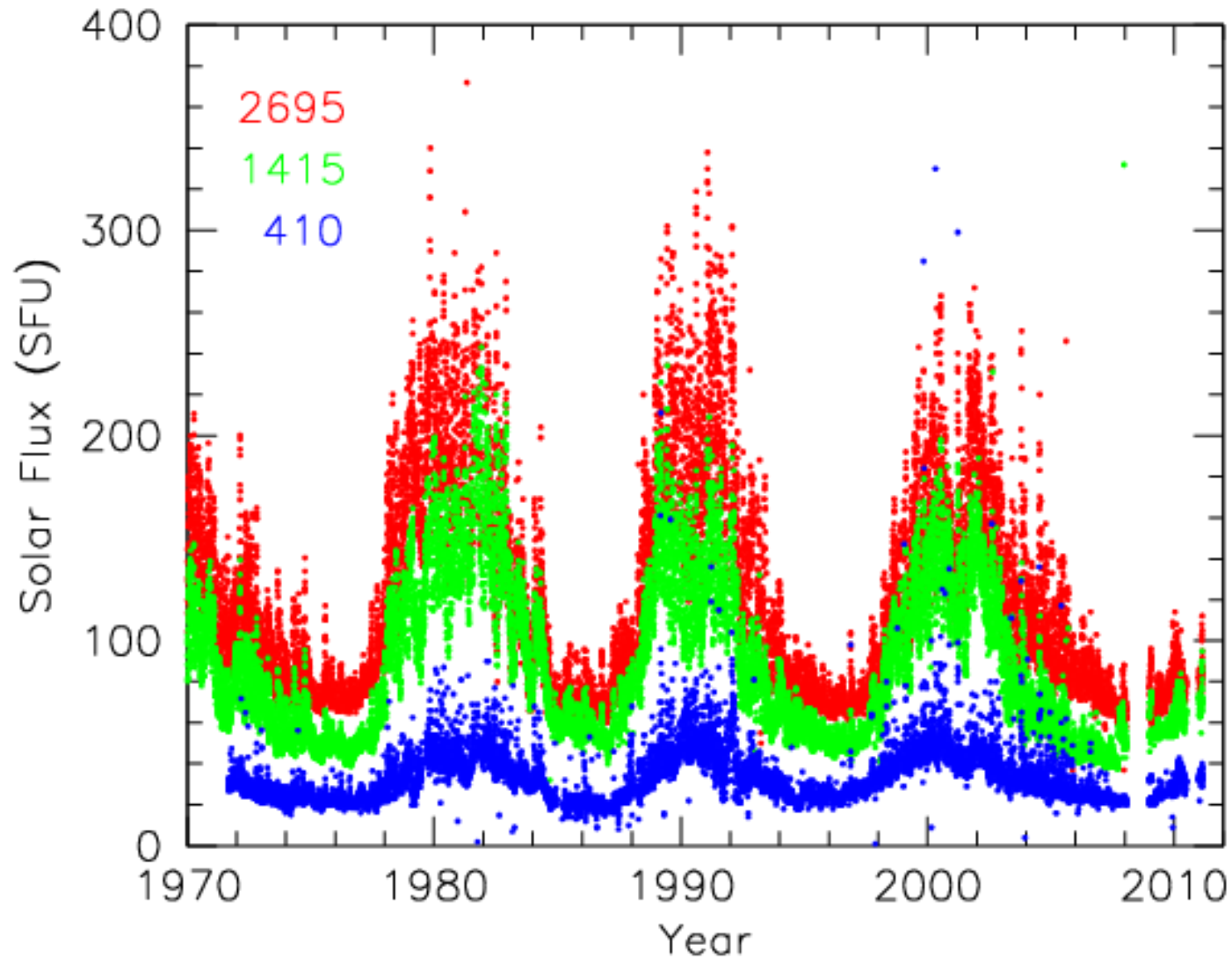
# Summary

- Small, lightweight, rugged antenna
- Easy to point in Az, El
- Easy to build; moderate cost
- Many EME QSOs in past few weeks
- No “Faraday lockouts”
- Able to work its twin, nearly any time

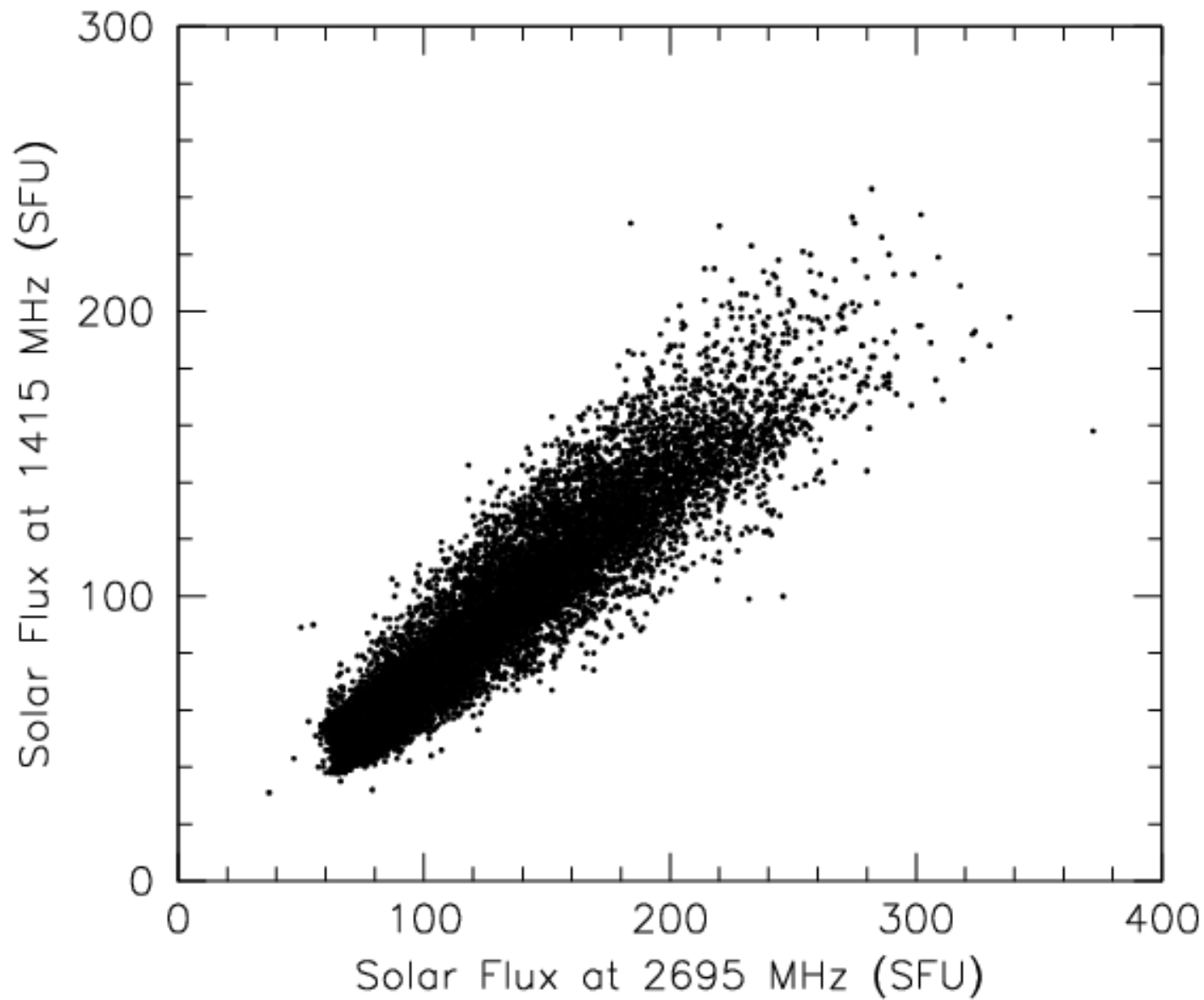
**W2PU**  
**70 cm EME**



# Beware use of 10.7 cm Solar Flux !

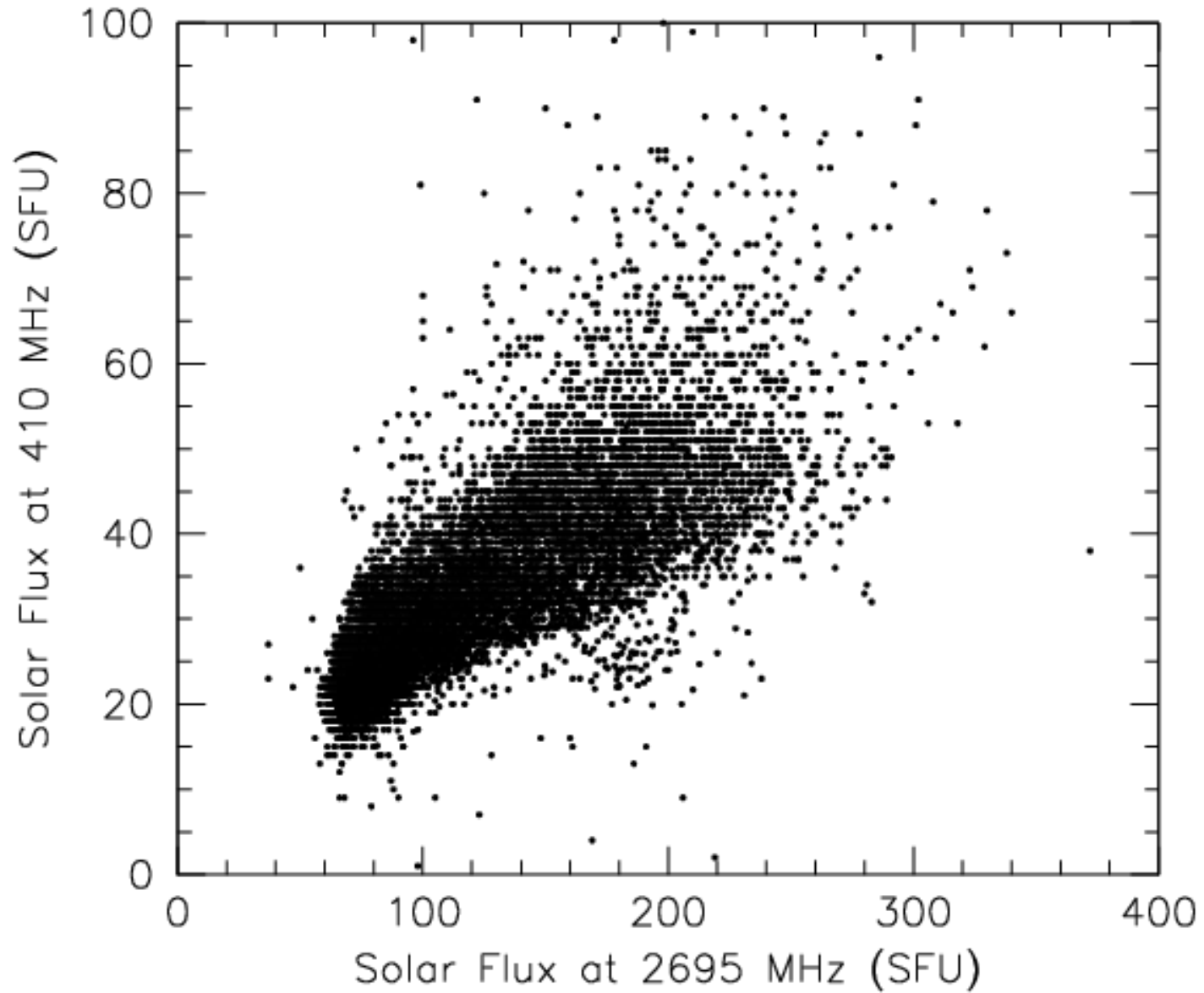


# $S_{1415}$ vs. $S_{2695}$





# $S_{410}$ vs. $S_{2695}$





# Drift curve of Sun

