Spectral Requirements and Interference Excision in Broadband Radio Telescopes

Dynamic range

- Digital signal processing assumes linearity
- Noise power to max power margin
  - fiber modem: kTB = –43 + log(BW in GHz) dBm
  - common amplifiers prefer max of –10 to 0 dBm
- Digital conversion range (6 dB per bit)

Frequency resolution

- Gaps between RFI signals ($\leq 0.1\%$ resolution desirable)

Time resolution

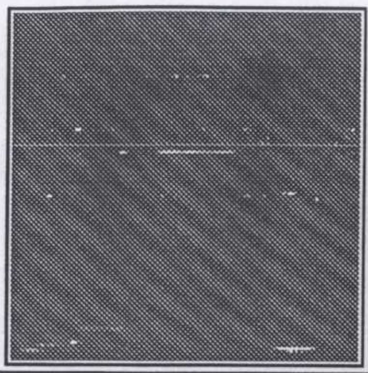
- Adaptive canceling time scales (milliseconds)
- Radar? (microseconds)
  - peak power 30 dB above average

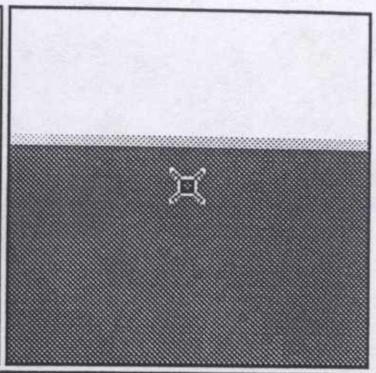
RFI excision options

- Blanking (time or frequency)
- Coherent cancellation
- Null-steering
- Post-correlation

Self interference!!

file: BIMG1998_09_18_00:34:08_Sp.fits
dir: .





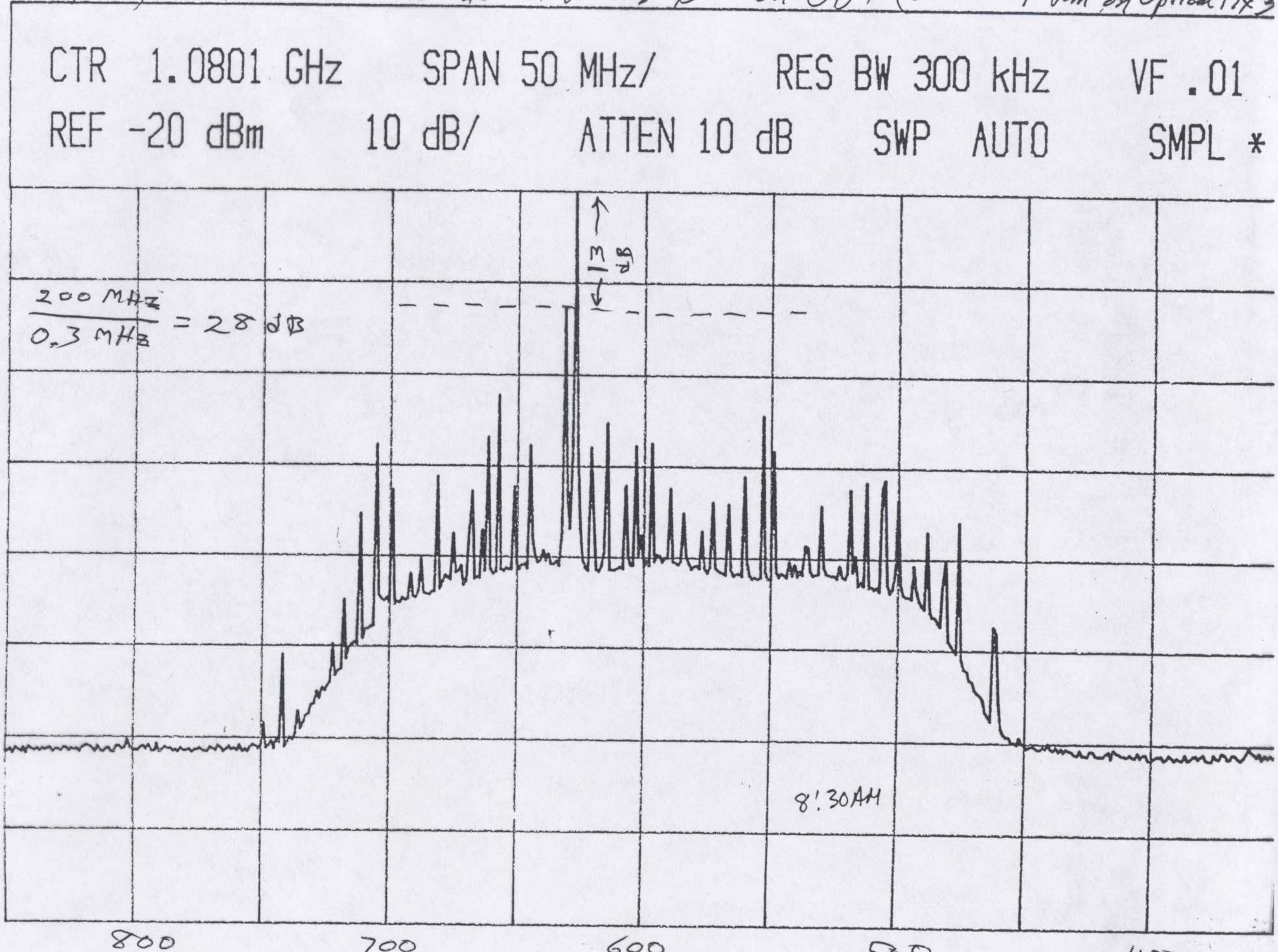
6.0 483.0 5

39 MHz

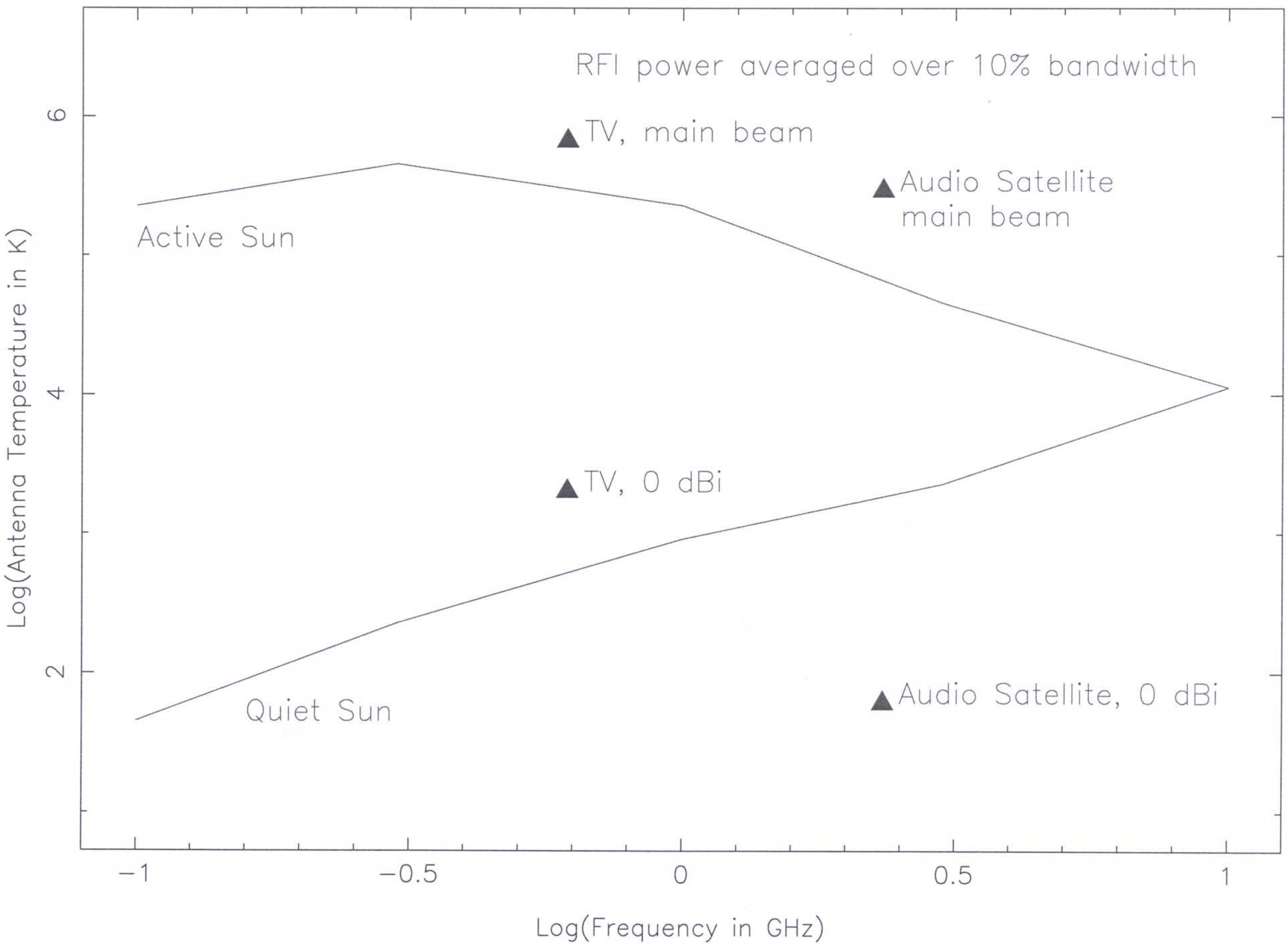
29 MHz

← approx. 2 hours →

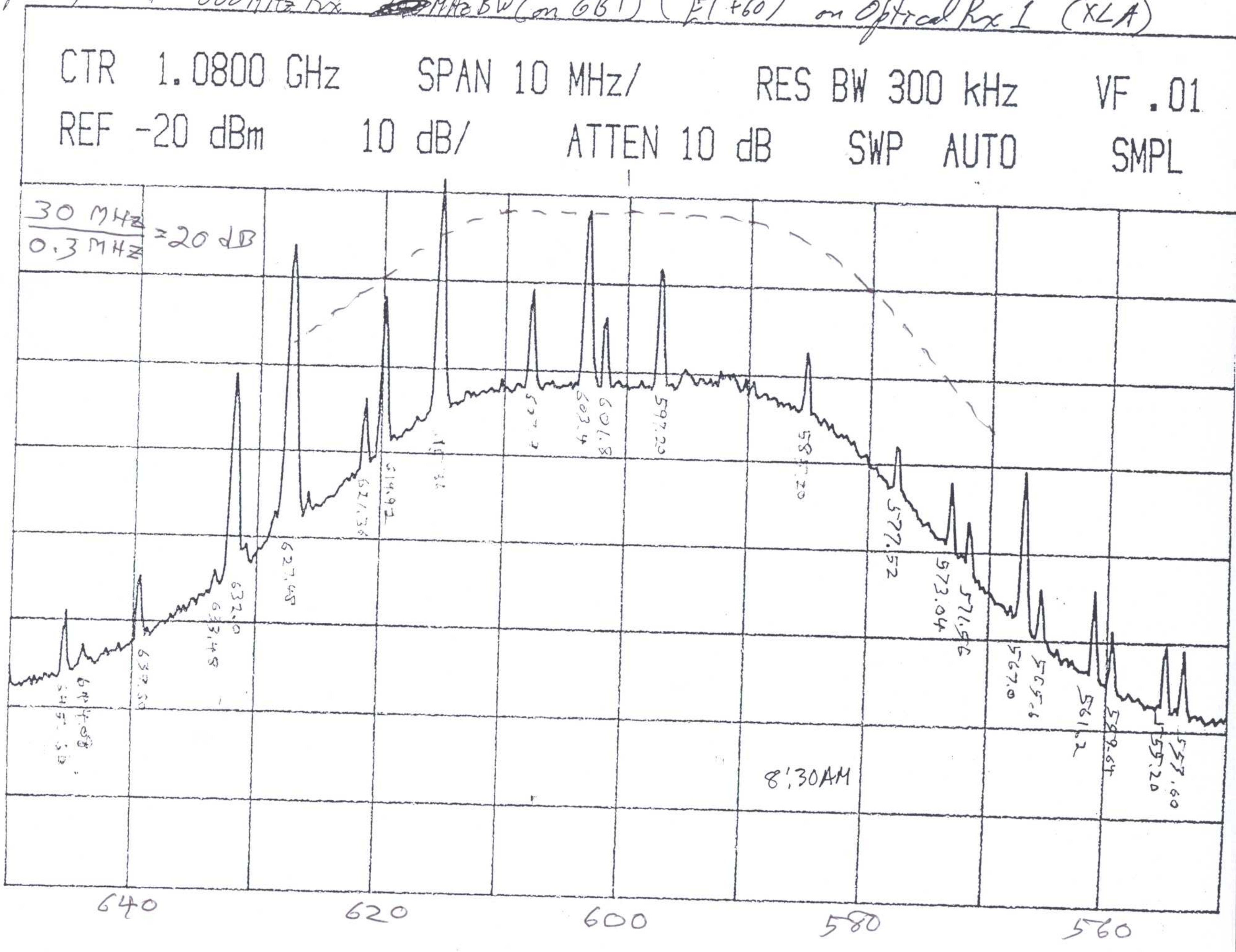
Sept 17, 2001 LO = 1680 MHz 600 MHz Rx 240 MHz BW on GBT (Az +66°, El +80°) as a [illegible] in Control Rm on Optical Fix

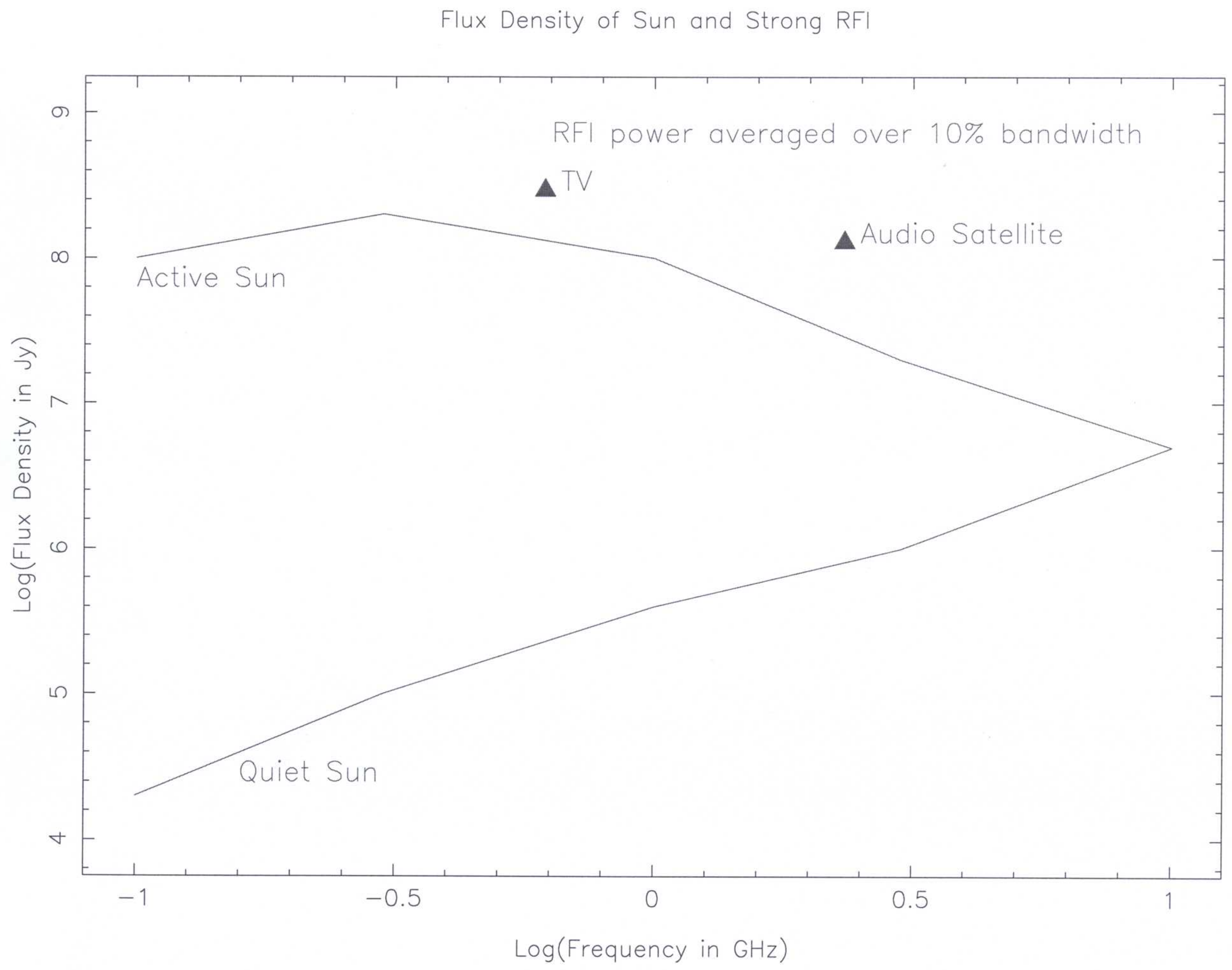


Four–Meter Antenna Temperature of Sun and Strong RFI

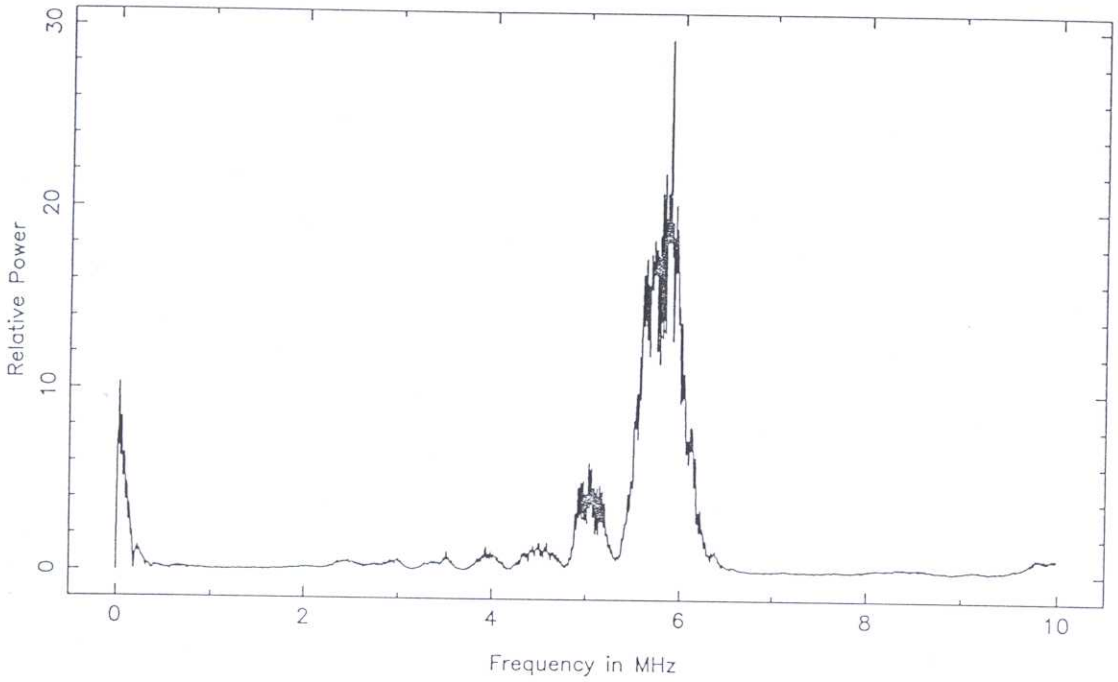


LO = 1680 MHz
Sept 17, 2004 600 MHz Rx ~~200~~ 20 MHz BW (on GBT) (Az +66, El +60) as seen in Control R[oom] on Optical Rx 1 (XLA)

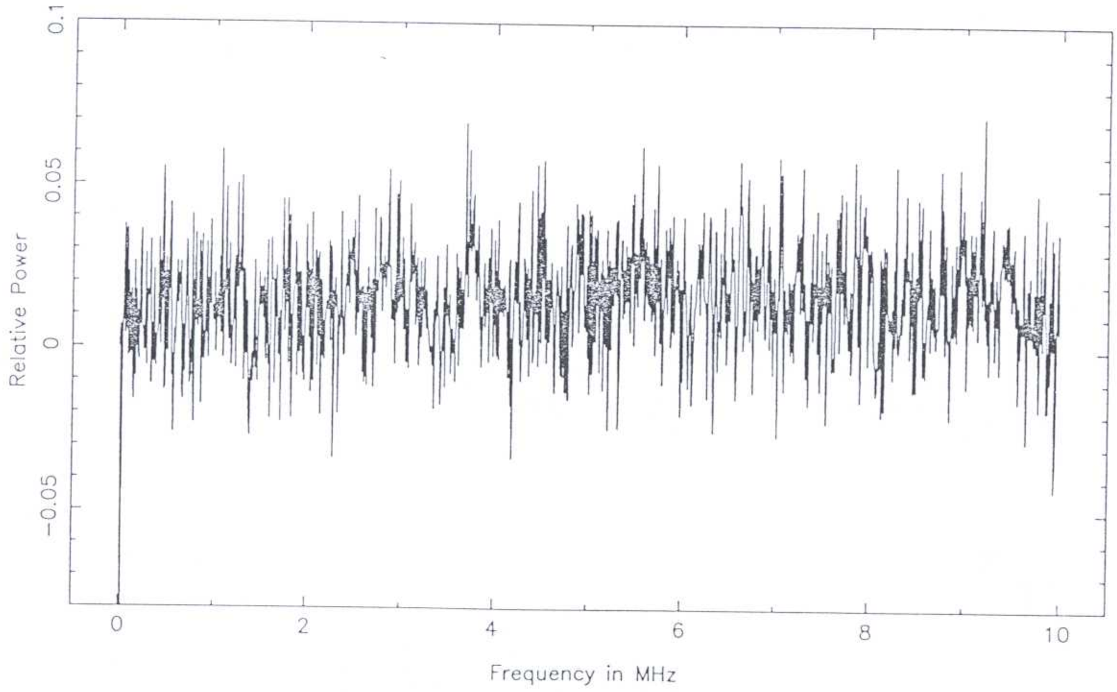



Flux Density of Sun and Strong RFI
RFI power averaged over 10% bandwidth
TV
Audio Satellite
Active Sun
Quiet Sun
Log(Flux Density in Jy)
9
8
7
6
5
4
−1
−0.5
0
0.5
1
Log(Frequency in GHz)

ARSR-3 RADAR Spectrum, clip: F fraction: 1



ARSR-3 RADAR Spectrum, blanked 150 us, 0.95 – 1.25 sec

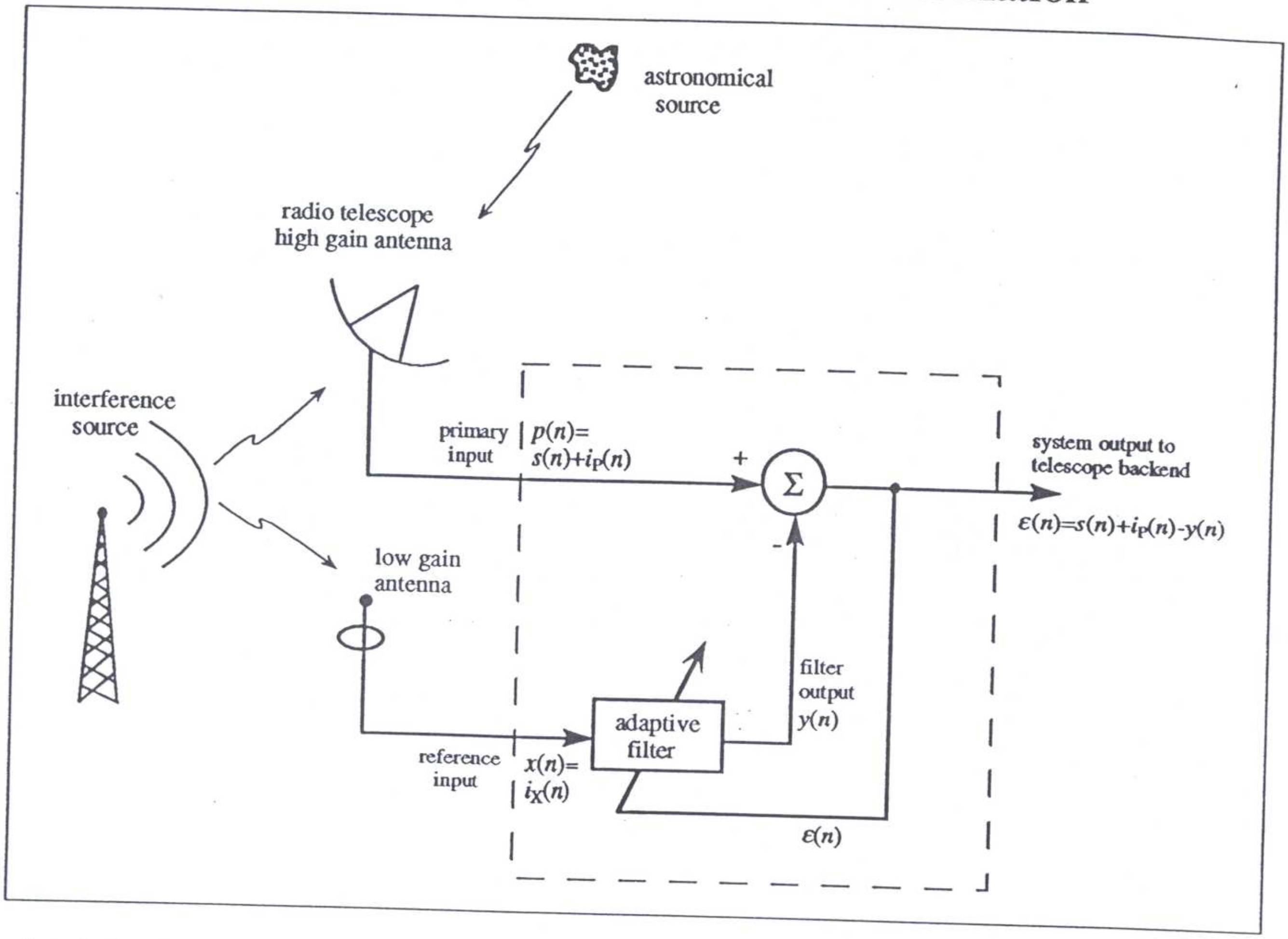


Real-Time RFI Excision

- Added information
  - Signal properties
  - Better sample of RFI
  - Optimized weak RFI detection
- Blanking
  - 1 to 1000 milliseconds
  - Detection (and tracking) task
  - Non-contiguous-samples spectrometers?
- Cancellation
  - Adaptive filter
    - High signal-to-noise reference RFI sample
    - Complex delay compensation and tracking
  - Parametric
    - *A priori* signal knowledge of signal
    - Solution and tracking of limited number of parameters
      - E.g., delay, phase, Doppler, intensity of GLONASS

Figure 2

Concept of Adaptive Interference Cancellation



An ideal adaptive interference canceling system for use on a radio telescope is shown above. The telescope receiver, located at the prime focus, forms the primary input to the canceler. This input consists of the desired astronomical signal, $s(n)$, entering through the main beam, as well as undesired interference, $i_P(n)$, entering through the telescope sidelobes. A second receiver connected to an low-gain antenna forms the reference input, $x(n)$, to the canceler. This input consists of only the interference, $i_X(n)$, which is uncorrelated with the astronomical signal but correlated in some unknown way with the interference in the primary channel. In the reference channel, the interference is filtered to produce the output, $y(n)$, that is a close replica to $i_P(n)$. This filter output is subtracted from the primary input, $s(n) + i_P(n)$, to produce the system output, $\varepsilon(n)$. Minimizing the total output power in $\varepsilon(n)$ will minimize the output interference power *in real time*.

Real-Time RFI Excision (continued)

- Null-steering
  - Similar to adaptive cancellation
    - Same signal-to-noise requirements
  - Single dish with auxiliary antennas
  - Multi-element arrays
    - Possible astronomical signal degradation
- Post-correlation cancellation
  - Phase preserved in correlation process
  - Best when correlation with good RFI reference channel
  - After data recorded
    - Can try different parameters
    - Less computationally intensive
  - Requires large correlator
- Small but active research field
  - http://www.atnf.csiro.au/SKA/intmit