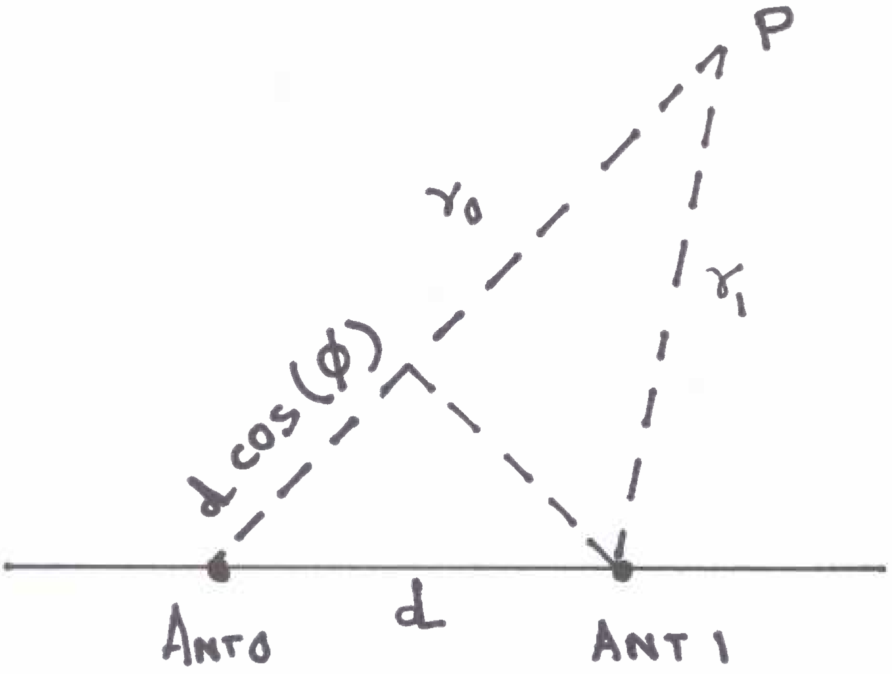
PHASED ARRAY

WE CAN OBTAIN BETTER SENSITIVITY BY USING AN ANTENNA ARRAY



PHASE FACTOR

$r_1 = r_0 - d\cos(\phi)$

PHASOR SUM OF THE FIELDS DUE TO ANT 0 & ANT 1

$$E = E_0 \left(1 + e^{i\psi}\right)$$

$$\psi = \frac{2\pi}{\lambda} d\cos(\phi) + \delta$$

δ = phase difference between Ant 0 and Ant 1, d = spacing between

FOR N antennas

$$E = E_0 \left(1 + e^{i\psi} + e^{i2\psi} + \dots + e^{i(N-1)\psi}\right]$$

$$E = E_0 \frac{\sin(N\psi/2)}{\sin(\psi/2)} e^{i(N-1)\psi/2}$$

If the phase centre is chosen to be at the centre of the array

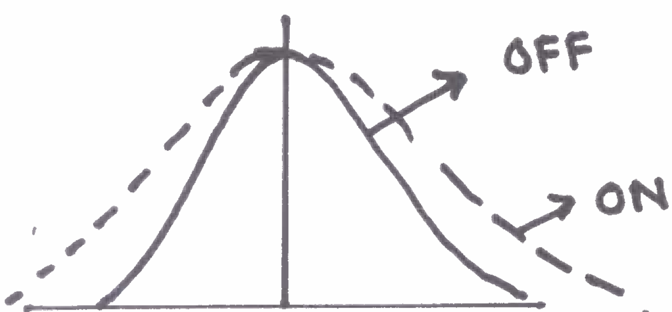
$$E = E_0 \frac{\sin(N\psi/2)}{\sin(\psi/2)}$$

As $\psi \to 0$

$$E = N E_0$$

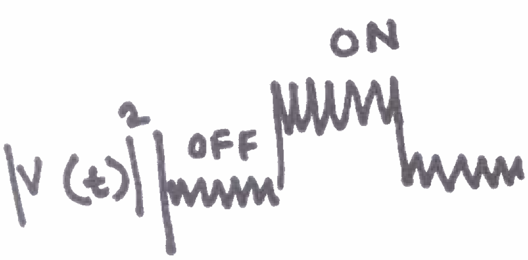
This is the maximum value of the field and is N times that of a single antenna.

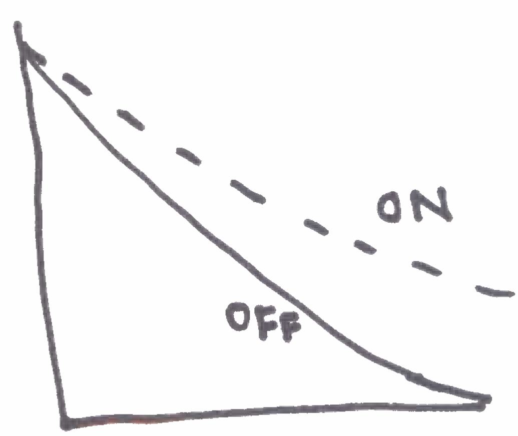
THE VOLTAGE PATTERN AVAILABLE AT THE ANTENNA TERMINAL IS GAUSSIAN RANDOM NOISE



Gaussian Distribution

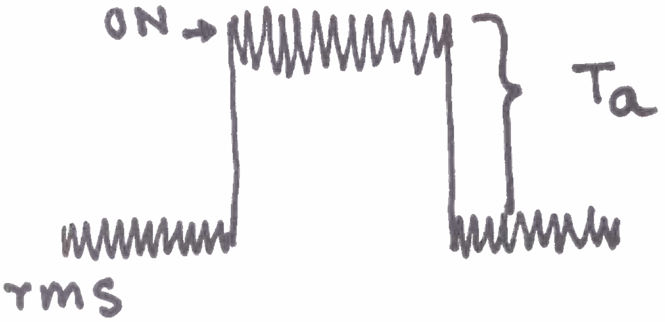
When the signal is detected, one measures $|V(t)|^2$





Distribution is positive

SIGNAL TO NOISE RATIO



OFF $\sim T_{sys}$

$$SNR = \frac{ON - OFF}{rms} = \frac{ON - OFF}{OFF} \cdot \frac{OFF}{rms}$$

$$= \frac{T_a}{T_{sys}} \times \frac{T_{sys}}{rms}$$

$$T_a = \frac{1}{2} \frac{A_e}{k} S = G\,S$$

If $\Delta\nu$ is the bandwidth of observation 2 samples taken at interval less than $\Delta t = \frac{1}{\Delta\nu}$ are not independent.

In time τ # of independent samples are $N = \frac{\tau}{\Delta t} = \tau\,\Delta\nu$

Error in the mean of the estimate of T_{sys} in time τ

$$\frac{T_{sys}}{} = rms$$

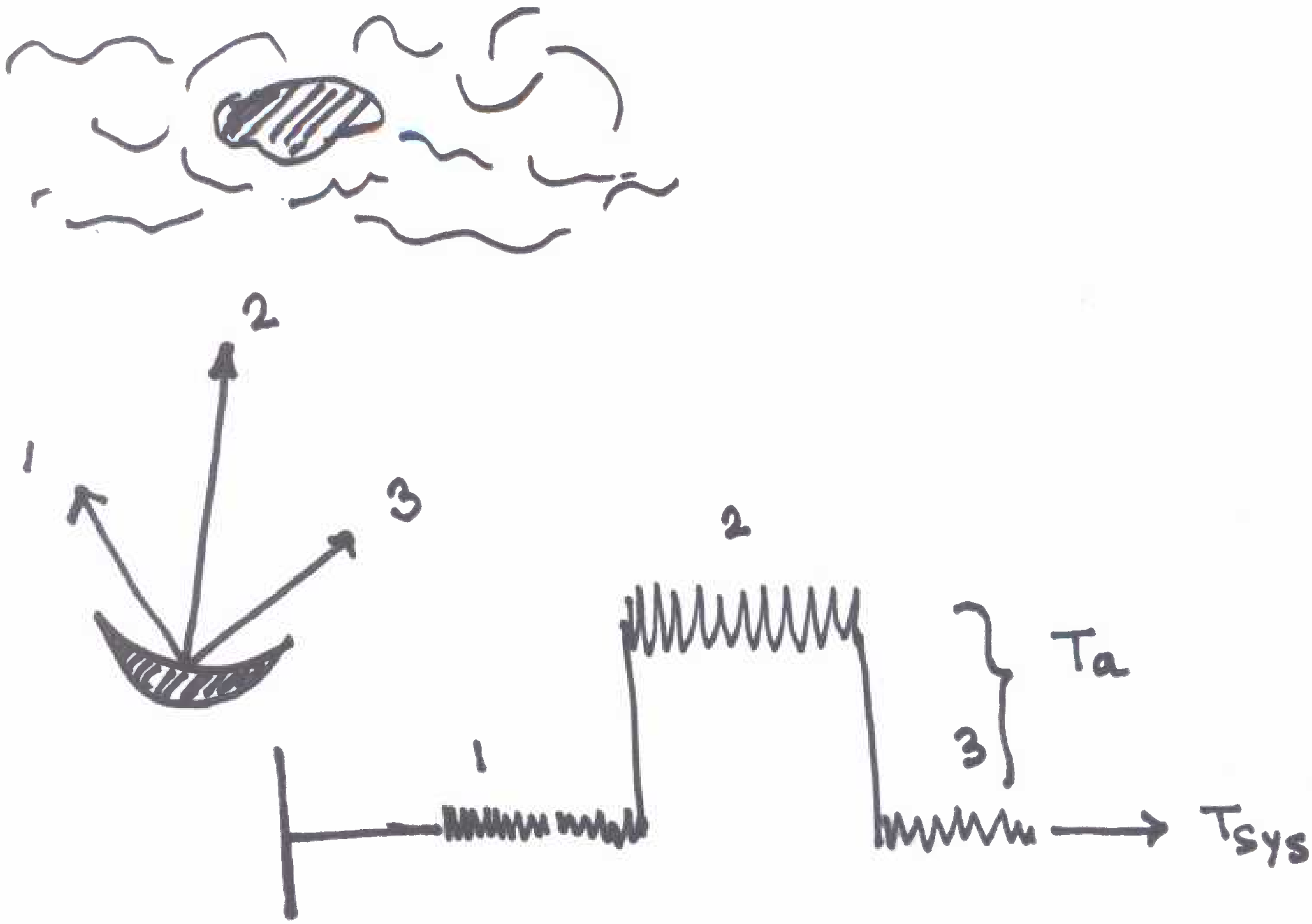
$$SNR = \frac{GS}{T_{sys}} \sqrt{\tau \, \Delta\nu}$$

SNR for incoherent addition

$$SNR_I = \frac{GS}{T_{sys}} \sqrt{\Delta\nu \, \tau \, N}$$

SNR for coherent addition

$$SNR_c = \frac{N \, GS}{T_{sys}} \sqrt{\Delta\nu \, \tau}$$



T_a = ANT TEMP + INCREASE IN POWER DUE TO SOURCE

$$T_{sys} = T_{sky} + T_{spill} + T_{loss} + T_{rec}$$

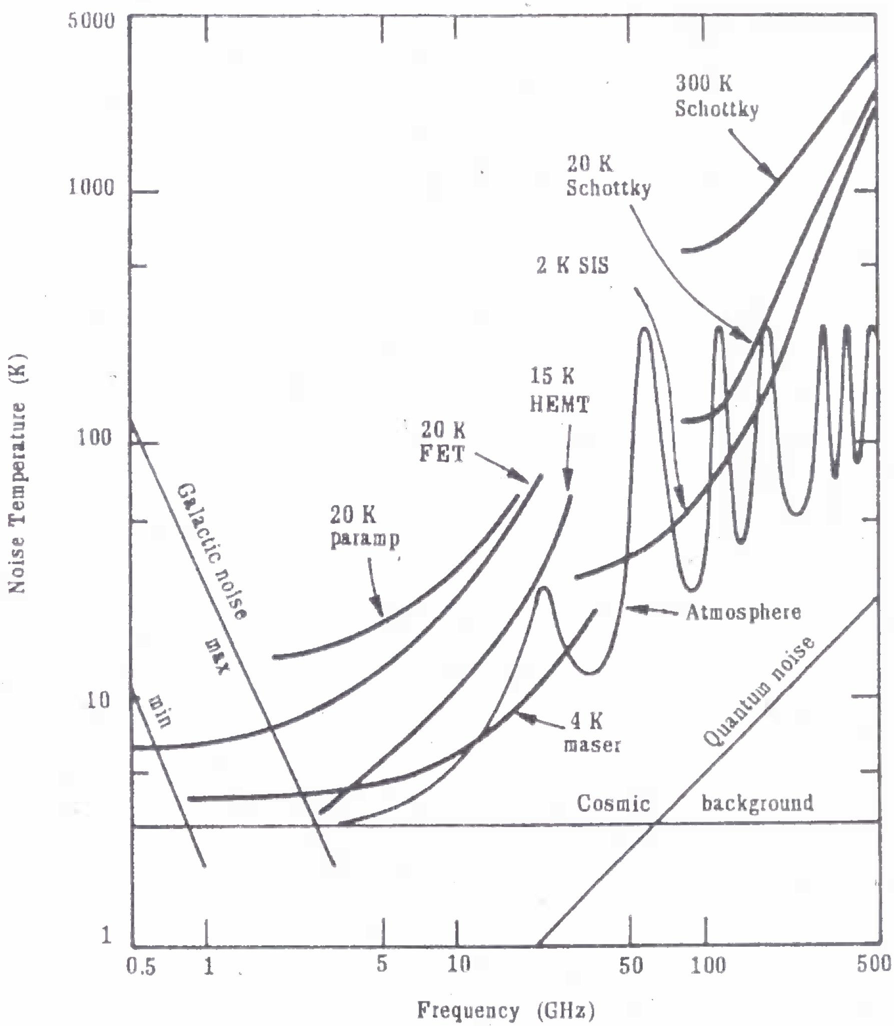
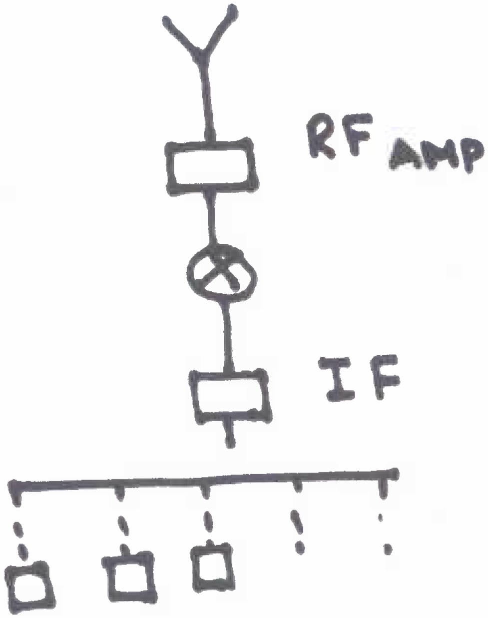


Fig. 7-25. State-of-the-art noise temperatures of some low-noise receivers as of 1985 compared with natural noise contributions. Quantum-noise temperature $= h\nu/k = 0.048\ \nu_{\mathrm{GHz}}$.

SPECTRAL RECEIVERS

1. IF voltage output goes to filters tuned to Different central frequencies.



— Difficult to maintain

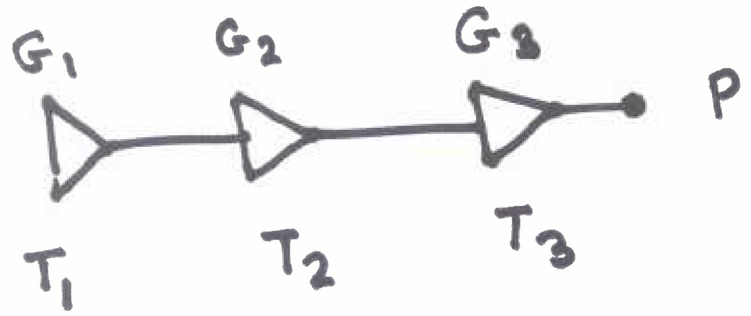
2. DIGITAL TECHNIQUES

TAKE N CONSEQUTIVE SAMPLES VOLTAGE IN TIME & DO A FFT, TO GET THE SPECTRUM.

Receiver Temperature

In a telescope there are components like amplifiers which generates lot of noise and contribute to the system temperature.

For a cascade of Amplifiers



$$P = k\left[G_3 T_3 + G_3 G_2 T_2 + G_1 G_2 G_3 T_1\right]$$

$$= k\, G_1 G_2 G_3 \left[T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1 G_2}\right]$$

The noise temperature of the first amplifier dominates. So for a good receiver system the first amplifier should have low noise high gain.

In Reality sensitivity is limited by gain instabilities

$\Rightarrow$ Signals received from celestial source are low, so the gains are high $\sim 10^{14}$,

So small changes in gains produce large instabilities

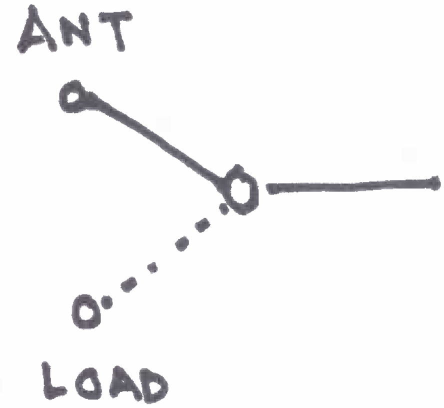
$$W = K(T_A + T_{sys})\, G\, \Delta\nu$$

$$W + \Delta W = K(T_A + T_{sys})(G + \Delta G)\Delta\nu$$

$$\sim K(T_A + \Delta T + T_{sys})\, G\, \Delta\nu$$

$$\frac{\Delta T}{T_{sys}} = \frac{\Delta G}{G}$$

Dicke switching is used to overcome this problem.



$$W_A = k(T_A + T_{sys}) G \Delta\nu$$

$$W_R = k(T_R + T_{sys}) G \Delta\nu$$

$$W_A - W_R = k(T_A - T_R) G \Delta\nu$$

Now if ΔG variation is wrongly interpreted as ΔT variation

$$k(T_A - T_R)(G + \Delta G)\Delta\nu = k(T_A + \Delta T - T_R) G \Delta\nu$$

or $$\frac{\Delta T}{T_{sys}} = \frac{\Delta G}{G} \frac{T_A - T_R}{T_{sys}}.$$