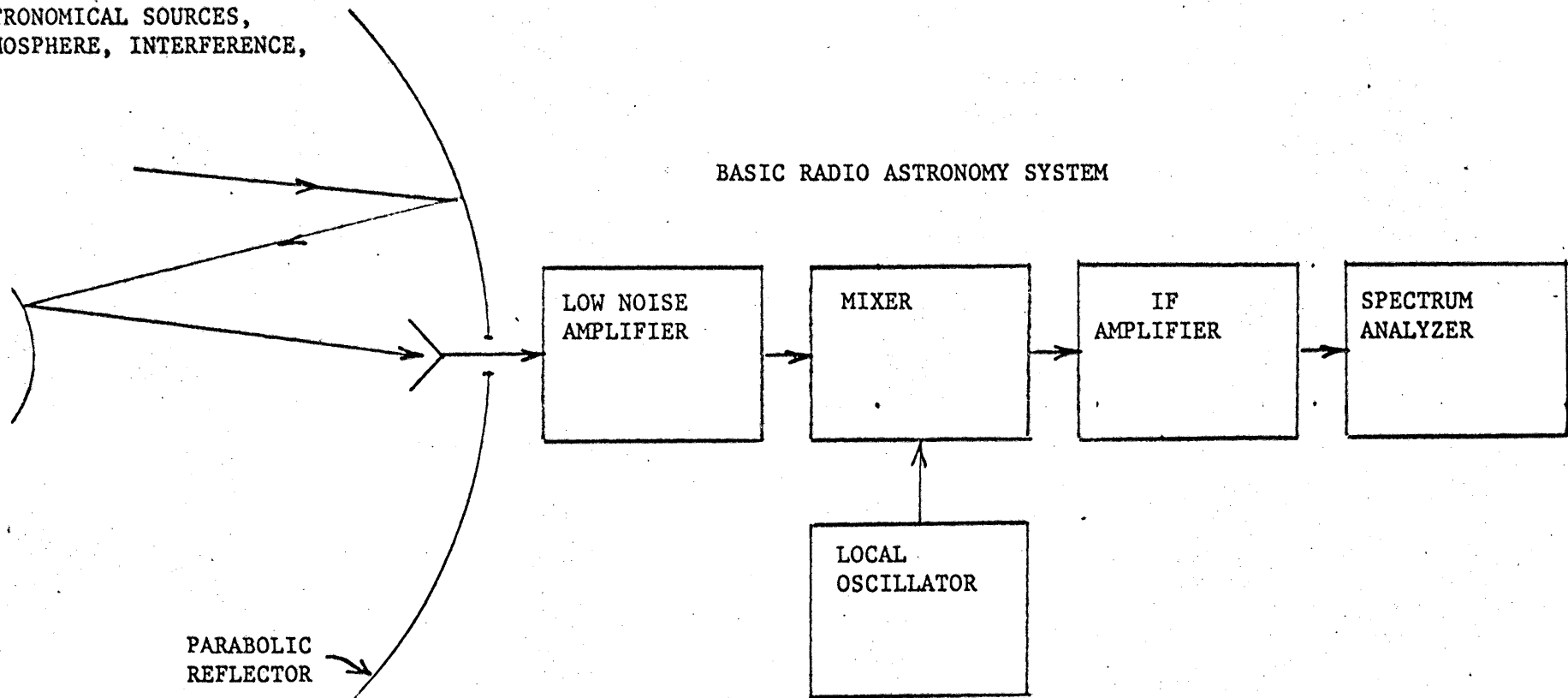


RADIO WAVES FROM:  
ASTRONOMICAL SOURCES,  
ATMOSPHERE, INTERFERENCE,

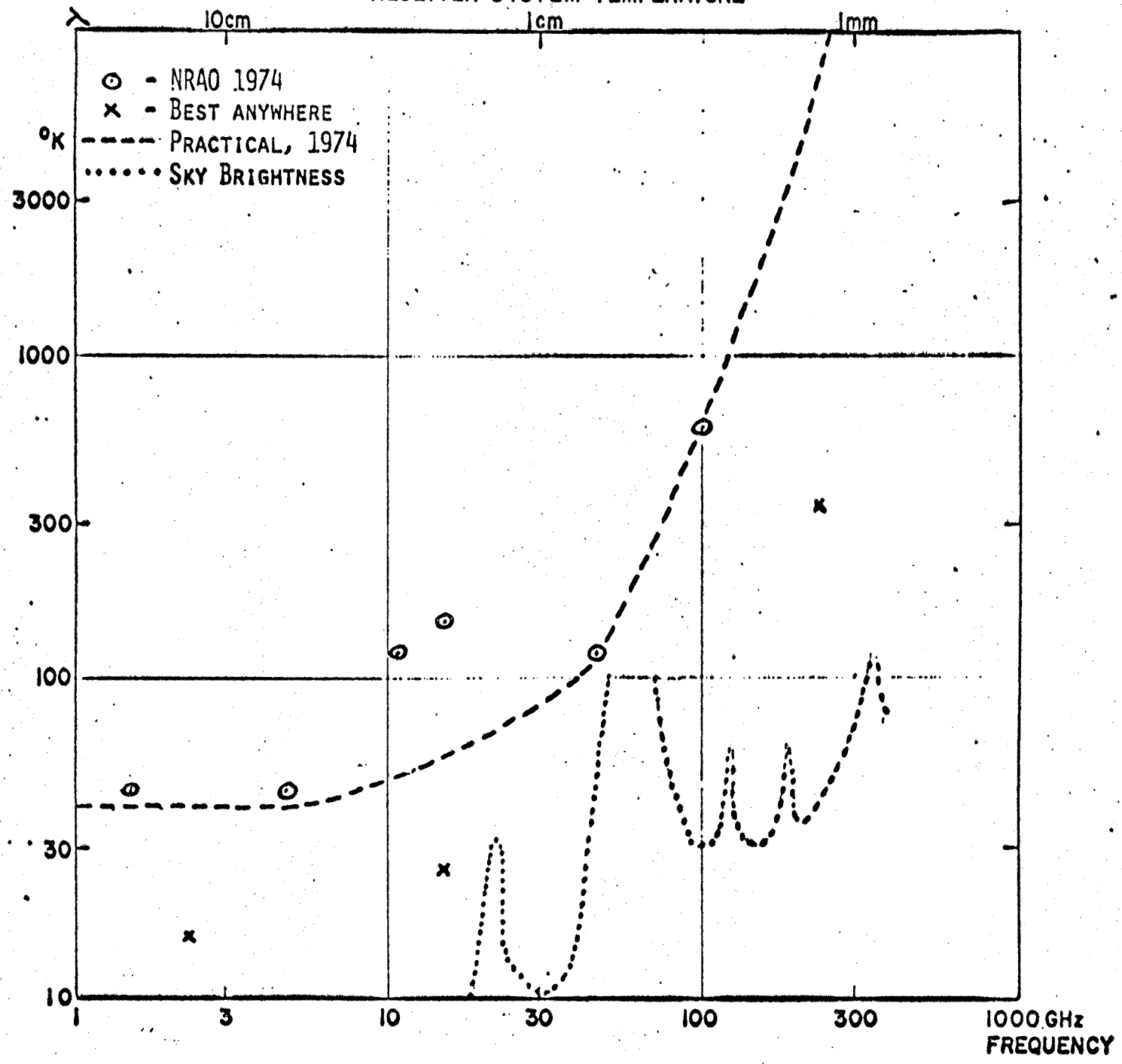


#### PROBLEM AREAS

- 1) IN CM RANGE LOW-NOISE AMPLIFIERS LIMIT SENSITIVITY AND TEND TO BE UNRELIABLE.
- 2) IN MM- $\lambda$  RANGE LOW-NOISE AMPLIFIERS DO NOT EXIST; EFFICIENT MIXERS MUST BE DEVELOPED.
- 3) MM- $\lambda$  LOCAL OSCILLATORS ARE EXPENSIVE, UNRELIABLE AND DO NOT EXIST FOR SHORT MM- $\lambda$  RANGES.
- 4) SPECTRUM ANALYZERS COVERING GHZ BANDWIDTHS WITH  $\sim 10^4$  CHANNELS ARE NEEDED.

LECTURE NOTES  
S. WEINREB  
6/21/79

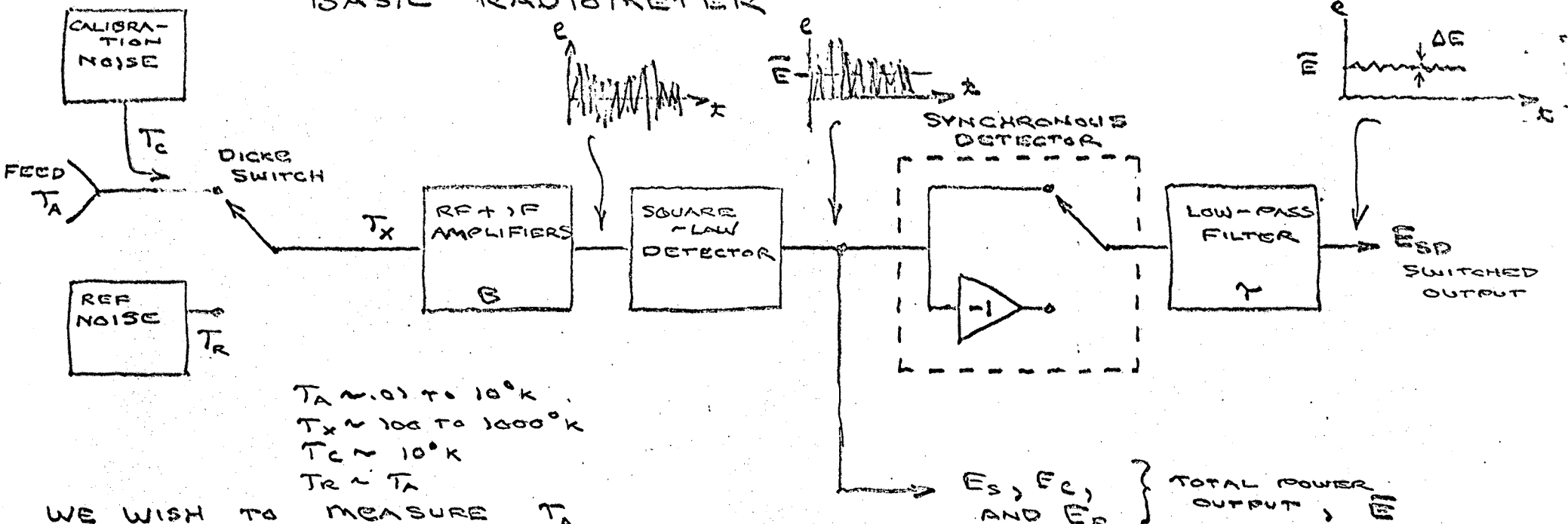
# RECEIVER SYSTEM TEMPERATURE



FET AMPLIFIER PERFORMANCE

FREQUENCY GHZ	1978 BEST ACHIEVED		1981 PREDICTED	
	ROOM TEMP	CRYO- GENIC	ROOM TEMP	CRYO- GENIC
.610	65	25	40	10
1.4-1.7	45	12	40	10
4.5-5	90	30	60	15
15	250 <sup>o</sup>	80 <sup>o</sup>	120	40
22	400 <sup>o</sup>	-	150	60

# BASIC RADIOMETER



$T_A \sim 0.01 \text{ TO } 10^4 \text{ K}$   
 $T_x \sim 100 \text{ TO } 1000^4 \text{ K}$   
 $T_C \sim 10^4 \text{ K}$   
 $T_R \sim T_A$

WE WISH TO MEASURE  $T_A$

$E_S, E_C, E_R$  } TOTAL POWER OUTPUT,  $E$

BASIC INPUT - OUTPUT RELATION  $\rightarrow$

$$\left( \begin{array}{c} \text{AVERAGE} \\ \text{DETECTOR} \\ \text{OUTPUT} \\ \text{VOLTAGE,} \\ E \end{array} \right) = \left( \begin{array}{c} = G \\ \left( \begin{array}{c} K \\ \uparrow \\ 1.38 \times 10^{-23} \end{array} \right) \left( \begin{array}{c} B \\ \uparrow \\ \text{NOISE} \\ \text{BANDWIDTH} \end{array} \right) \left( \begin{array}{c} G' \\ \uparrow \\ \text{TOTAL} \\ \text{POWER} \\ \text{GAIN} \end{array} \right) \end{array} \right) \times \left( \begin{array}{c} \text{TOTAL} \\ \text{INPUT} \\ \text{NOISE} \\ \text{TEMPERATURE} \end{array} \right)$$

SWITCH UP, CAL OFF  $\rightarrow$   $E_S = G(T_x + T_A)$  SIGNAL VOLTAGE

SWITCH UP CAL ON  $\rightarrow$   $E_C = G(T_x + T_A + T_C)$  CALIBRATION VOLTAGE

SWITCH DOWN CAL OFF OR ON  $\rightarrow$   $E_R = G(T_x + T_R)$  REFERENCE VOLTAGE

3 EQUATIONS, 3 UNKNOWN (  $T_A, G, T_x$  )

## SENSITIVITY LIMITATIONS

①

RMS  
MEAN

$$\frac{\Delta E}{E} = \frac{\Delta T_A}{T_x + T_A} = \frac{1}{\sqrt{B \cdot T}}$$

LIMIT DUE TO STATISTICAL  
FLUCTUATIONS OF NOISE

↑  
NOISE  
BANDWIDTH

↑  
INTEGRATION  
TIME

②

$$\frac{\Delta G}{G} \sim 1\%$$

LIMIT DUE TO RECEIVER GAIN STABILITY

## MODIFICATIONS TO BASIC RECEIVER

① DICKE SWITCHING - SYNCHRONOUS DETECTION

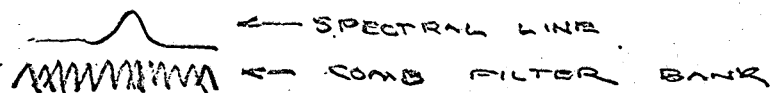
$$\bar{E}_{SD} = E_S - E_R = G(T_A - T_R)$$

② COMPUTER SYNCHRONOUS DETECTION

$$T_A = \frac{\bar{E}_S - \bar{E}_R}{\bar{E}_C - \bar{E}_S} \cdot T_C + T_R$$

③ MULTICHANNEL LINE RECEIVER

- COMB FILTERS AND MULTIPLE DETECTORS



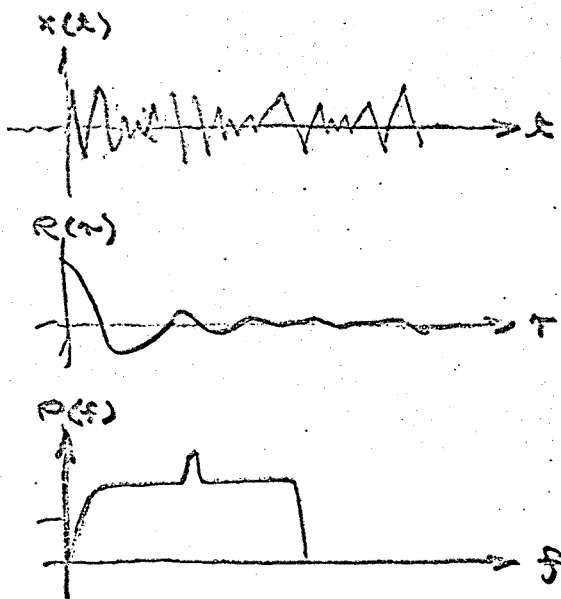
# AUTOCORRELATION RECEIVERS

$$T(f) = \int_{-\infty}^{\infty} R(\tau) \cos 2\pi f \tau d\tau$$

TEMPERATURE SPECTRUM  
 $T(f)$  AS FOURIER  
 TRANSFORM OF  
 AUTOCORRELATION FCN;  $R(\tau)$

$$R(\tau) = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t) x(t+\tau) dt$$

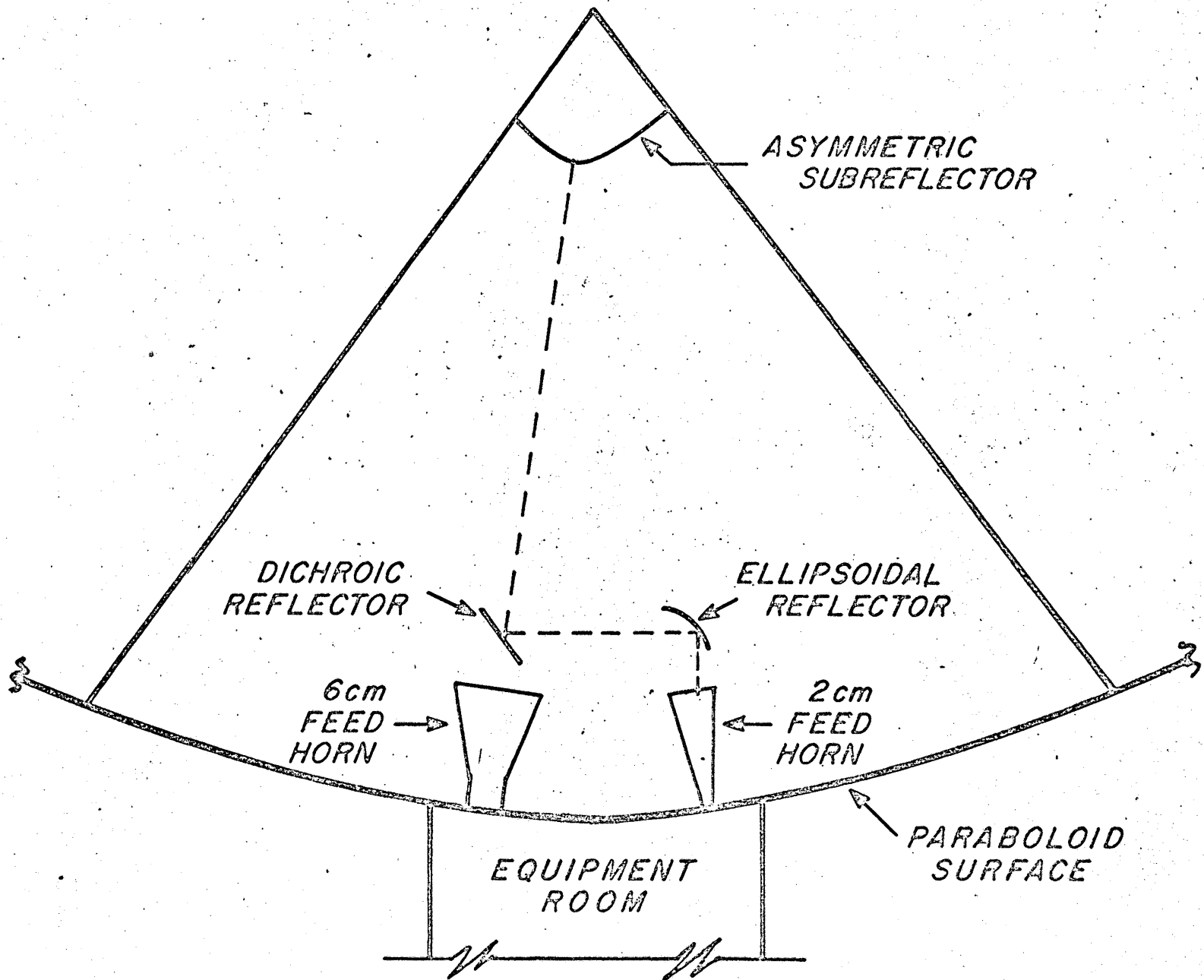
DEFINITION OF  $R(\tau)$  IN  
 TERMS OF SIGNAL TIME  
 FUNCTION,  $x(t)$ .



## MODIFICATIONS TO THEORY

MODIFICATION	EFFECT
$T$ CANNOT $\rightarrow \infty$	FREQUENCY RESOLUTION $\Delta B \sim \frac{1}{T_{MAX}}$
$T$ CANNOT $\rightarrow \infty$	STATISTICAL FLUCTUATION $\frac{\Delta T}{T} = \frac{1}{\sqrt{BT}} \sim \sqrt{\frac{T_{MAX}}{T}}$
$R(\tau)$ IS SAMPLED IN STEPS OF $\Delta \tau$	$f_{MAX} = \frac{1}{2\Delta \tau}$
$x(t)$ IS SAMPLED IN STEPS OF $\Delta t$	NO EFFECT IF $f_{MAX} = \frac{1}{2\Delta t}$
$x(t)$ IS QUANTIZED IN $N$ BITS	$\frac{\Delta T}{T}$ SLIGHTLY INCREASED

# VLA FEED CONFIGURATION



# VLA FRONT-END CONFIGURATION

