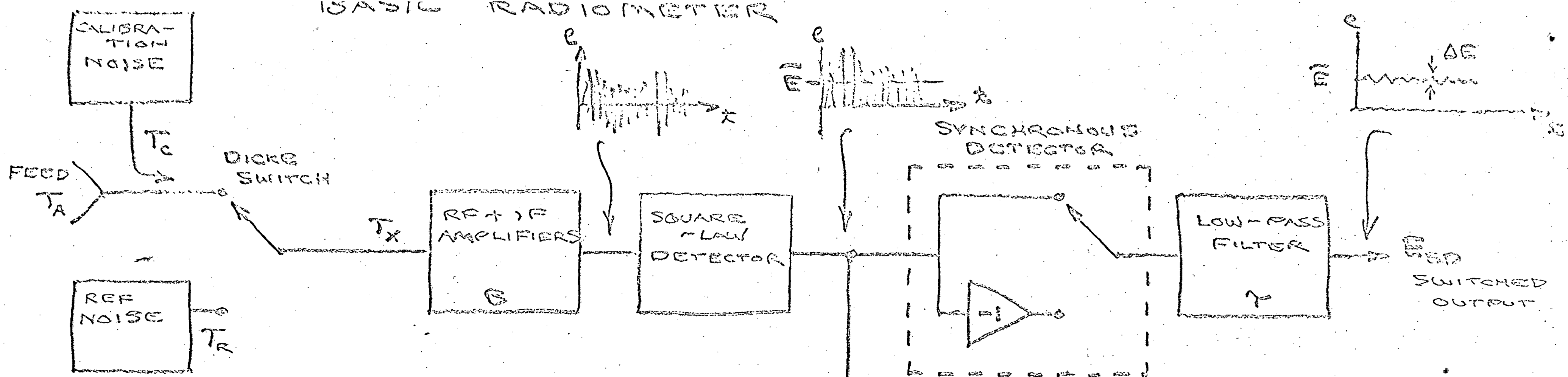
BASIC RADIOMETER



$T_A \sim .01$ to $10°K$
$T_X \sim 100$ to $1000°K$
$T_C \sim 10°K$
$T_R \sim T_A$

WE WISH TO MEASURE T_A

BASIC INPUT-OUTPUT RELATION ⟶ (AVERAGE DETECTOR OUTPUT VOLTAGE, $\bar{E}$) = (k B G') × (TOTAL INPUT NOISE TEMPERATURE)

where $k B G' = G$; $k = 1.38 \times 10^{-23}$; B = NOISE BANDWIDTH; G' = TOTAL POWER GAIN

SWITCH UP, CAL OFF ⟶ $\bar{E}_S = G(T_X + T_A)$ SIGNAL VOLTAGE

SWITCH UP CAL ON ⟶ $\bar{E}_C = G(T_X + T_A + T_C)$ CALIBRATION VOLTAGE

SWITCH DOWN CAL OFF OR ON ⟶ $\bar{E}_R = G(T_X + T_R)$ REFERENCE VOLTAGE

3 EQUATIONS, 3 UNKNOWNS (T_A, G, T_X)

LECTURE NOTES
S. WEINREB
June 18, 1973

SENSITIVITY LIMITATIONS

(1)

$$\frac{RMS}{MEAN} = \frac{\Delta E}{E} = \frac{\Delta T_A}{T_x + T_A} \approx \frac{1}{\sqrt{B\tau}}$$

LIMIT DUE TO STATISTICAL FLUCTUATIONS OF NOISE

(B = NOISE BANDWIDTH, τ = INTEGRATION TIME)

(2)

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

LIMIT DUE TO RECEIVER GAIN STABILITY

MODIFICATIONS TO BASIC RECEIVER

(1) DICKE SWITCHING - SYNCHRONOUS DETECTION

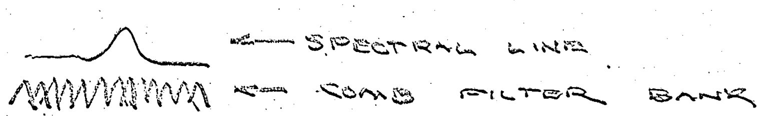
$$\bar{E}_{SD} = E_S - E_R = G(T_A - T_R)$$

(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



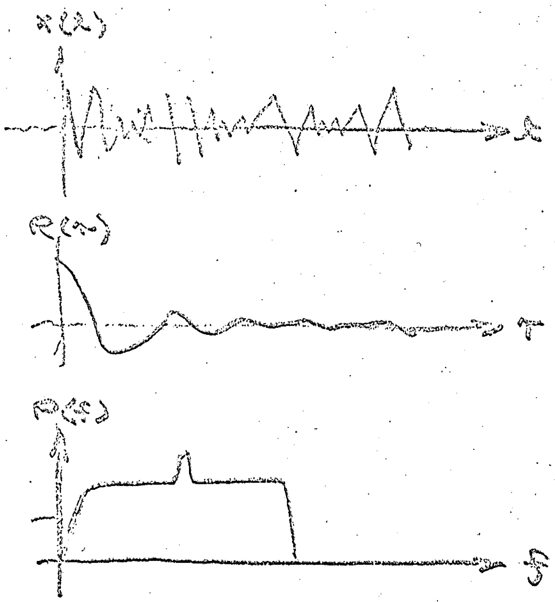
AUTOCORRELATION RECEIVERS

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

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

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

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



MODIFICATIONS TO THEORY

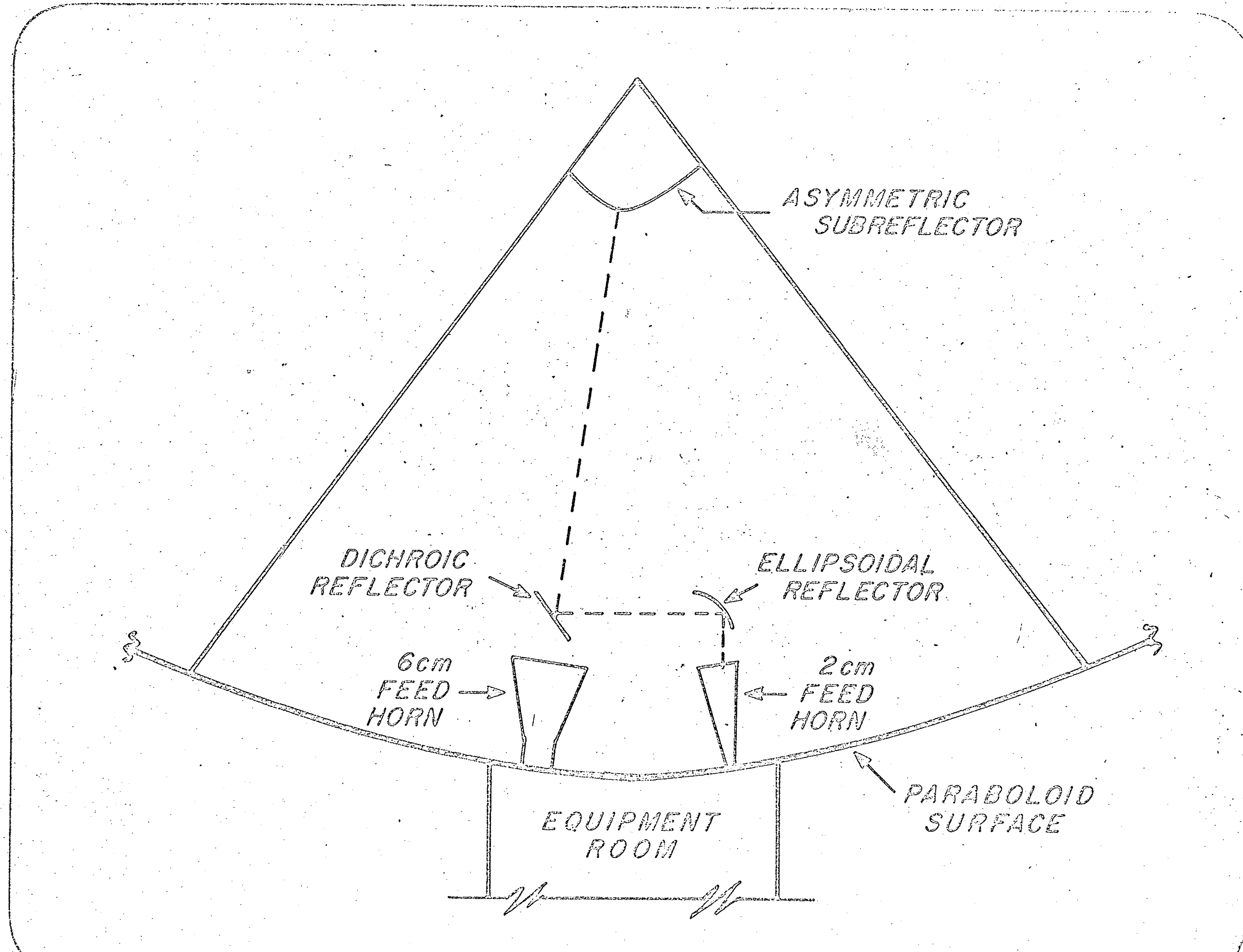
MODIFICATION	EFFECT
τ CANNOT $\to \infty$	FREQUENCY RESOLUTION $\Delta B \sim \frac{1}{\tau_{MAX}}$
T CANNOT $\to \infty$	STATISTICAL FLUCTUATION $\frac{\Delta T}{T} = \frac{1}{\sqrt{BT}} \sim \sqrt{\frac{\tau_{MAX}}{T}}$
$R(\tau)$ IS SAMPLED IN STEPS OF $\Delta\tau$	$f_{MAX} = \frac{1}{2\Delta\tau}$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

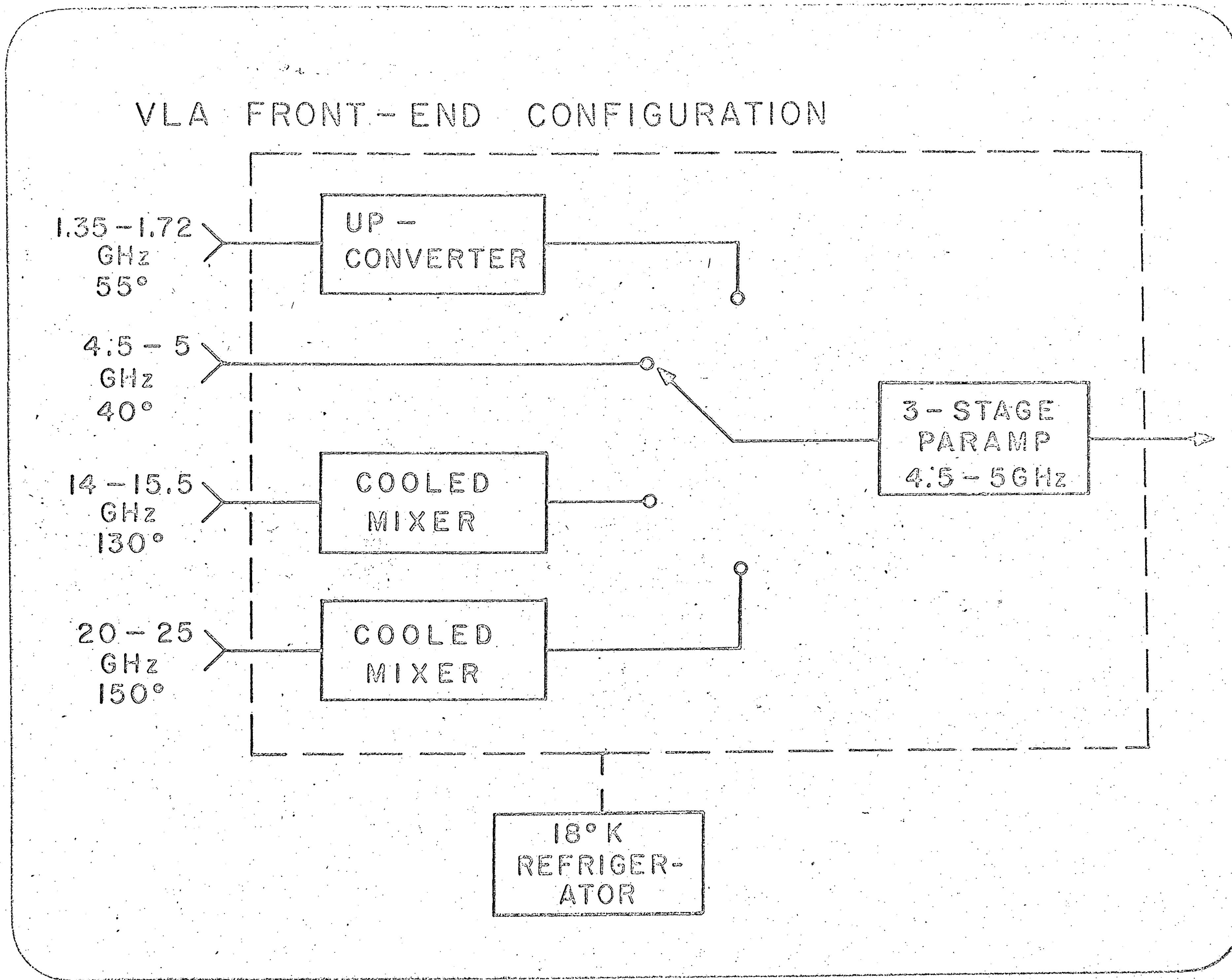
RADIOMETER SENSITIVITY

(For Rectangular IF Bandwidth, B, and Square Law Detector)

$\Delta T/T$	Case
$\frac{1}{\sqrt{B\tau}}$	Total Power Receiver, Ideal Integration For Time τ
$\frac{1}{\sqrt{2B\tau}}$	Total Power Receiver, $\tau \equiv$ RC Integrator
$\frac{2}{\sqrt{B\tau}}$	Square Wave Switched Receiver, Ideal Integrator
$\frac{2}{\sqrt{2B\tau}}$	Square Wave Switched Receiver, RC Integrator
$\frac{\pi}{2\sqrt{2}} \cdot \frac{2}{\sqrt{2B\tau}} = \frac{\pi}{2} \cdot \frac{1}{\sqrt{B\tau}}$	Square Wave Switched, Tuned Amplifier After Detector, RC Integrator

VLA FEED CONFIGURATION




VLA FRONT-END CONFIGURATION
1.35-1.72 GHz 55°
4.5-5 GHz 40°
14-15.5 GHz 130°
20-25 GHz 150°
UP-CONVERTER
COOLED MIXER
COOLED MIXER
3-STAGE PARAMP 4.5-5GHz
18°K REFRIGERATOR

VLA SIGNAL TRANSMISSION

TE_{01} MODE HELIX WAVEGUIDE TRANSMISSION SYSTEM