July 1981

CORNELL UNIVERSITY

Center for Radiophysics and Space Research

ITHACA, N. Y.

FINAL TECHNICAL REPORT

for

NASA-Ames Research Center

on

Cooperative Agreement NCC 2-79

PROTOTYPE Ge:Ga DETECTORS FOR THE NASA-AMES COOLED GRATING SPECTROMETER

May 1, 1980 - January 31, 1981

Principal Investigator: J. R. Houck

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I. INTRODUCTION:

Techniques for the routine fabrication of Ge:GA detectors were developed under this grant. Numerous detectors were fabricated and tested including seven elements mounted in cavities supplied by E. Erickson of NASA-Ames.

In addition to the usual infrared measurements of responsivity and noise, measurements were made of the detectors response to ionizing radiation. These results are attached as an appendix.

II. DETECTOR PREPARATION:

A. Material:

The detectors were fabricated from a Ge:Ga wafer from Eagle-Pitcher with a room temperature resistivity of $\sim 12\Omega$ cm. The wafer is approximately 2" in diameter and 0.061" thick.

B. Contacts:

The material was ion-implanted with Boron using 10^{14} ions/cm^2 at 25 Kev and 2×10^{14} ions/cm^2 at 50 Kev. The crystal was then sputter-cleaned and metalized first with sputtered Ti and then sputter Au.

C. Detector Chips:

The 2×2mm detector chips were cut using an abrasive saw. To remove saw damage the contacts were temporarily protected by a wax film and the sawn surfaces etched with CP-4. The chips were then indium-soldered into the detector cavities.

III. Detector performance:

Once the fabrication techniques were standardized, highly uniform detectors could be quickly produced. Typically, parameters from one detector to the next varied by ±10%. In general the characteristics are as follows:

R_I ($^{amp}/_{watt}$) $\sim$ 4.0† (DC)^{x}

V_N (R_L = 5E9) $\sim$ 7.5 μv^{*}

V_{BIAS} $\sim$ 0.2 v

†Averaged from 40 to 100 μm.

^{x}One can expect to achieve about 75% of the above responsivity at 20H_z.

*Background power of 5E-11 watts.

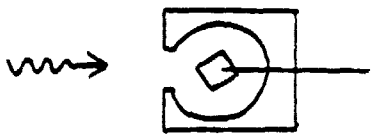
APPENDIX

TEST CONDITIONS

(1) Detector: Ge:Ga 2×2×1½ mm

Eagle-Picher; LC 1606 with ion implanted contacts.

(2) Cavity: Gold-plated copper 6 mm ϕ×1¾ mm deep entrance hole 1.34 (mm^2)



(3) Led: Standard red led with heat sink

Typical operation 0.5 ma
No detectable heat up at this current

(4) Optical System: OPI (see next two pages)

Signal power levels:

Low level: 1.5×10^{-13} w in band (with 2% filter)

High level: 5×10^{-11} w in band

Dark (slide closed $P_B << 10^{-14}$ w

(5) Signal Source: Chopped LN_2 "Black Body"

(6) Electronics:

Eltec load resistor

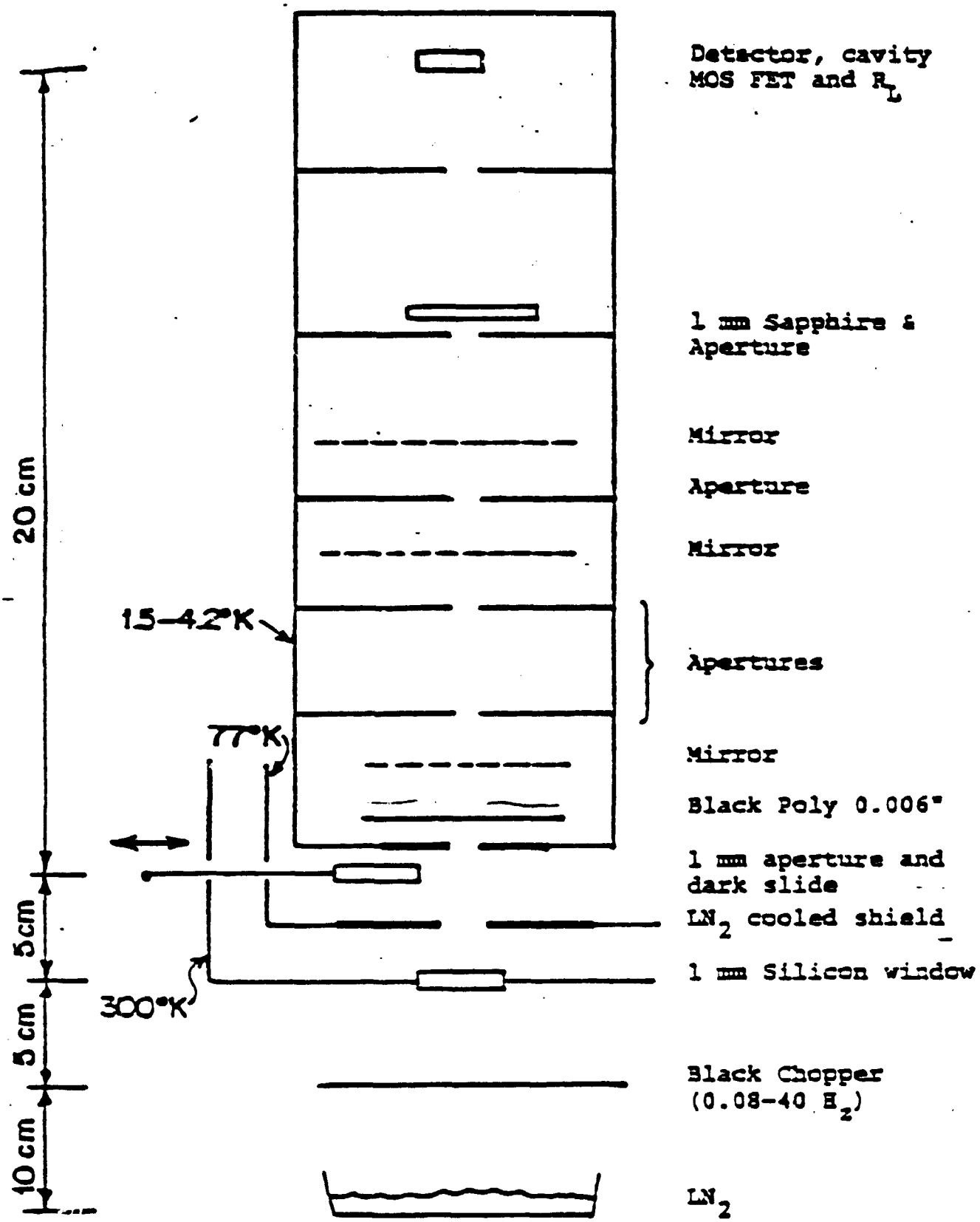
R(2°K) = 5×10^9 Ω

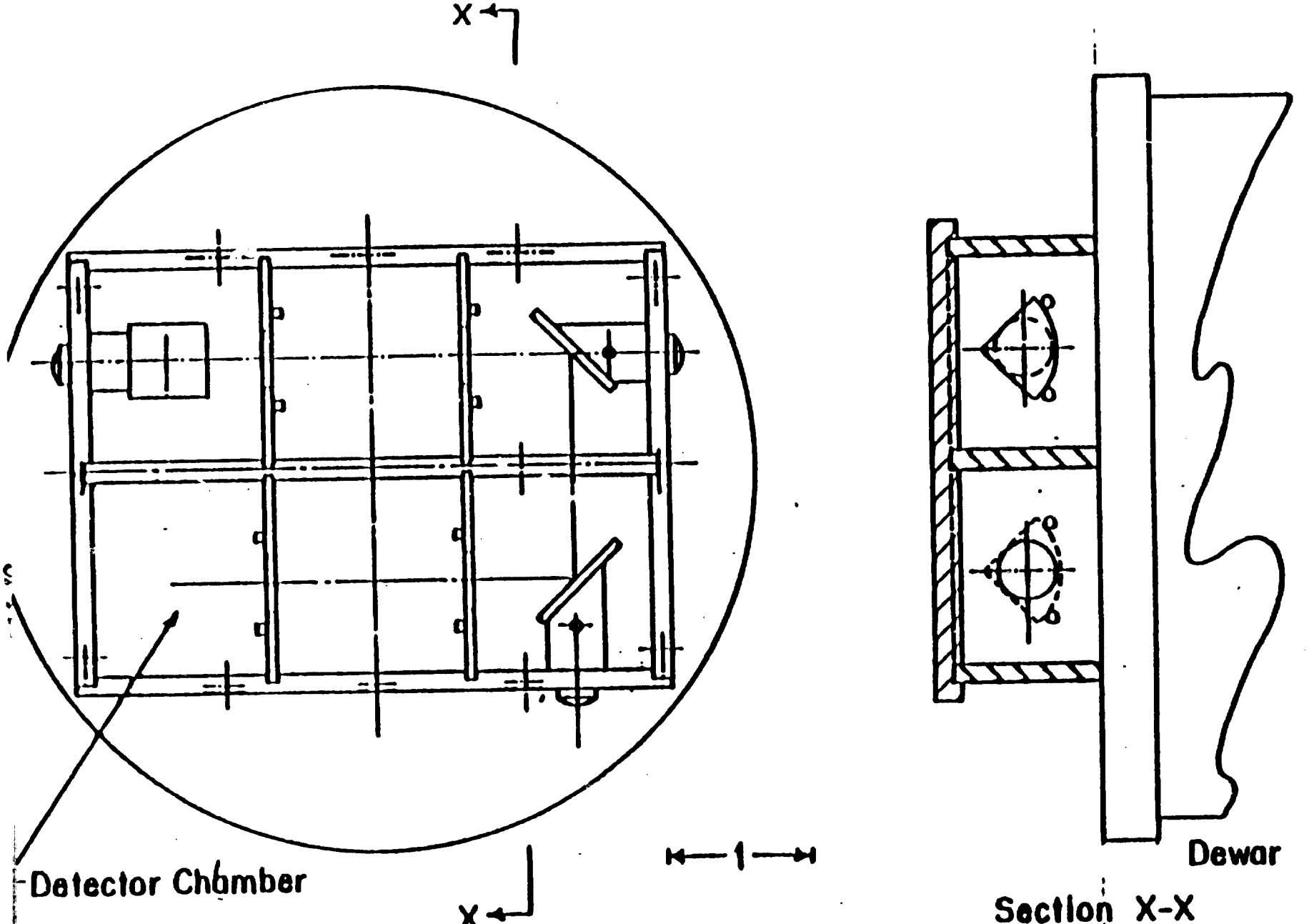
Standard TIA with

Balanced JFET (~100°K) 2N6484

OPTICAL PATH ("unfolded) OPI

CORNELL FILTERS




X
X
Detector Chamber
1
Dewar
Section X-X

TEST RESULTS

(1) Responsivity vs. LED-Induced Background:

The AC (20 H_z) and DC responsivities increased by 20x for a LED-induced photo current of 1.4×10^{-9} Amps (V_B = 250 mv) (The DC responsivity changed by less than 30% for an IR-induced photo current of the same magnitude.)

(2) Recovery Time:

The recovery time (the time required for the excess (LED induced) responsivity to decay to $1/e$) depends on many factors. These include temperature, IR background and bias voltage.

Test No.	T (Recovery)	Condition
1	∿36 minutes	Dark $P_B << 10^{-14}$w
2	"	Very low bkg; $P_B \sim 1.5\times10^{-14}$w
3	"	Low bkg; $P_B \sim 1.5\times10^{-13}$w
4	6.1 minutes	High bkg; $P_B \sim 5\times10^{-11}$w (Reduced bias 105 mv)
5	4 minutes	High bkg; $P_B \sim 5\times10^{-11}$w (Normal bias 200 mv)
6	6.3 minutes	Low bkg; 1.5×10^{-13}w 3.1°K
7	∿20 sec	V_B = 1.0 v - full breakdown

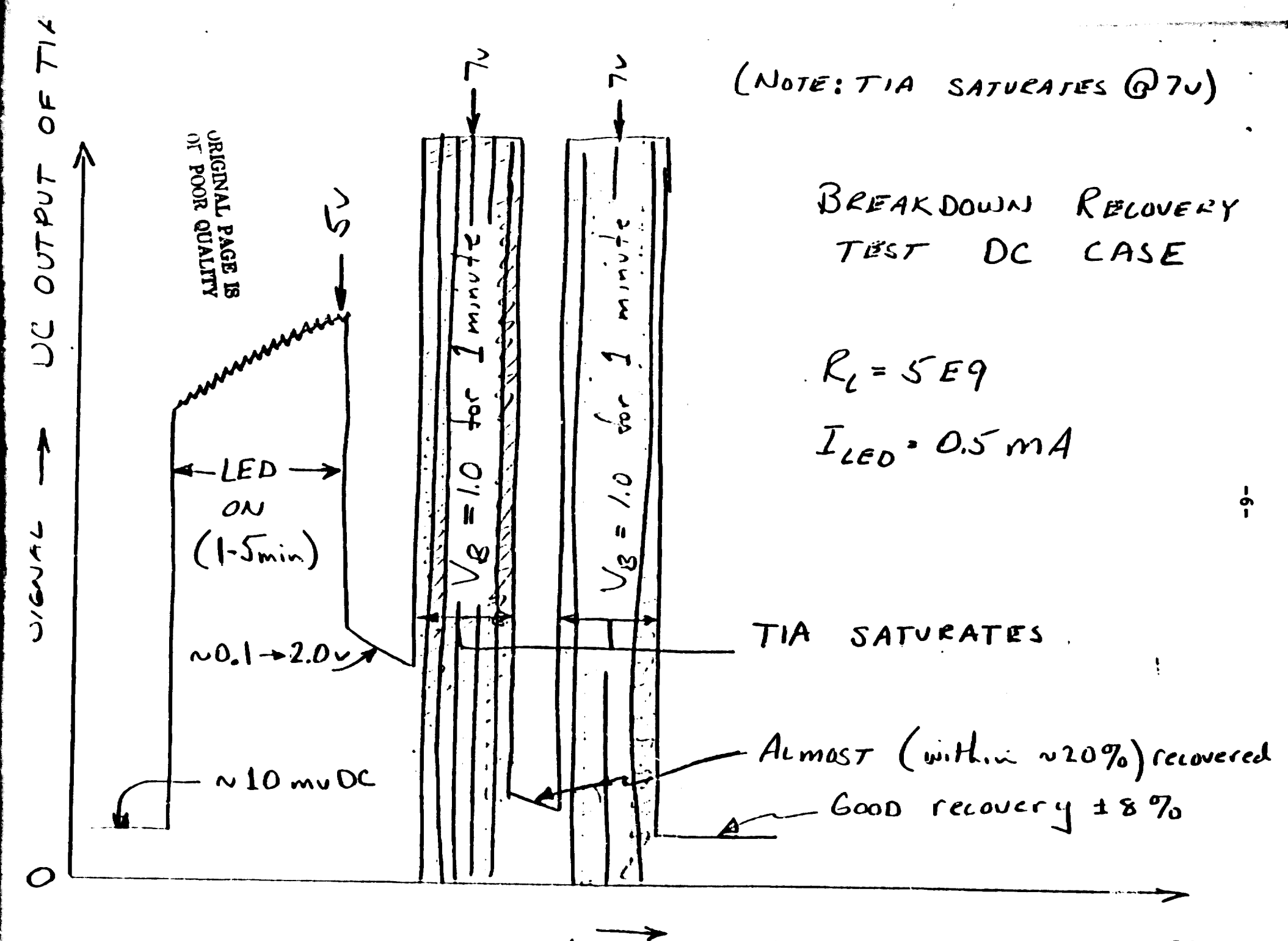
Tests 1,2,3,4,5 and 7: $T_{DET.} \lesssim 1.7$°K (T_{BATH} = 1.6°K)

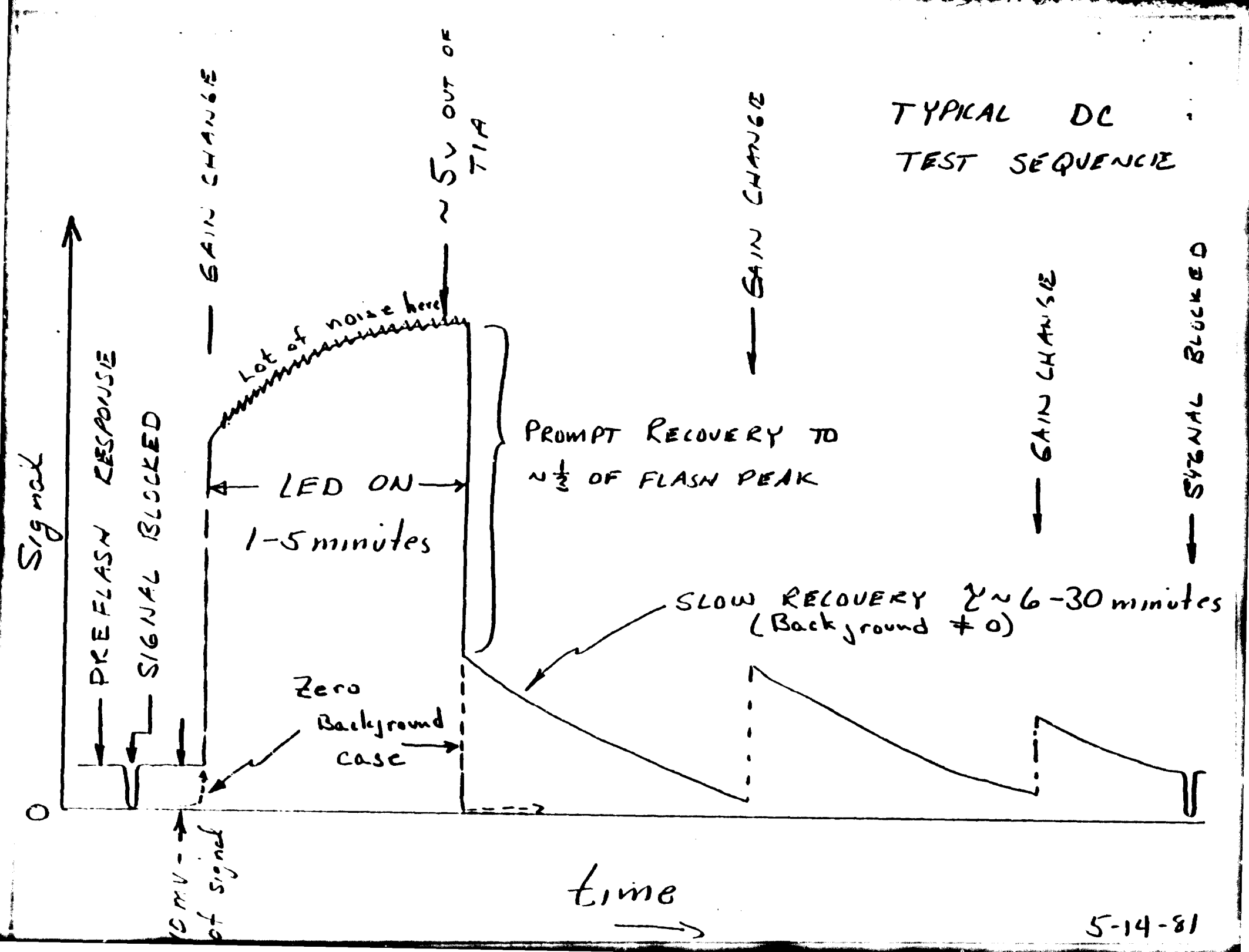
Conclusions:

(1) LED-induced-enhanced responsivity shows the same characteristics as γ-induced responsivity.

(2) Under low-background, low-temperature conditions the recovery time is very long, $\sim$ hours.

(3) Speedy recovery can be achieved by driving the detector into avalanche breakdown by increasing the bias.


(NOTE: TIA SATUREATES @ 7V)
BREAKDOWN RECOVERY TEST DC CASE
$R_L = 5E9$
$I_{LED} = 0.5\,mA$
ORIGINAL PAGE IS OF POOR QUALITY
SIGNAL → DC OUTPUT OF TIA
0
5V
7V
7V
LED ON (1-5min)
$V_B = 1.0$ for 1 minute
$V_B = 1.0$ for 1 minute
~0.1 → 2.0V
~10 mv DC
TIA SATUREATES
ALMOST (within ~20%) recovered
GOOD recovery ±8%


TYPICAL DC
TEST SEQUENCE
Signal
PREFLASH RESPONSE
SIGNAL BLOCKED
GAIN CHANGE
~5V OUT OF TIA
Lot of noise here
GAIN CHANGE
GAIN CHANGE
SIGNAL BLOCKED
LED ON
1-5 minutes
PROMPT RECOVERY TO ~½ OF FLASH PEAK
SLOW RECOVERY τ ~ 6-30 minutes
(Background ≠ 0)
Zero Background case
0
10 mV - of signal
time
5-14-81