In-lab Notes

> The notes you take while performing your in-lab work are a critical part of your experiment's record. They should be complete enough for you to be able recreate any set of your experiment conditions and repeat a measurement.

Your lab notebook is a working document, not a polished publication, but the writing must be reasonably legible and organized. The record in your lab notebook should be organized chronologically, or at least the time sequence of your various activities should be evident.

Your notebook, when combined with the course experiment notes, must be a complete record of the work you performed. All comments and data must be recorded only in the lab notebook – not on some separate document (other than computer data files). Computer printouts and other extra documentation (such as notes you recorded on separate sheets of paper or in a computer text file) must be attached to pages in your notebook.

> In-lab note taking will provide a permanent log of the exact configuration of the equipment and the settings you used to collect data. Any modifications to the course experiment notes' description of the equipment and their settings must be well described in you lab notebook, so that you know exactly how the equipment was configured for each particular measurement.

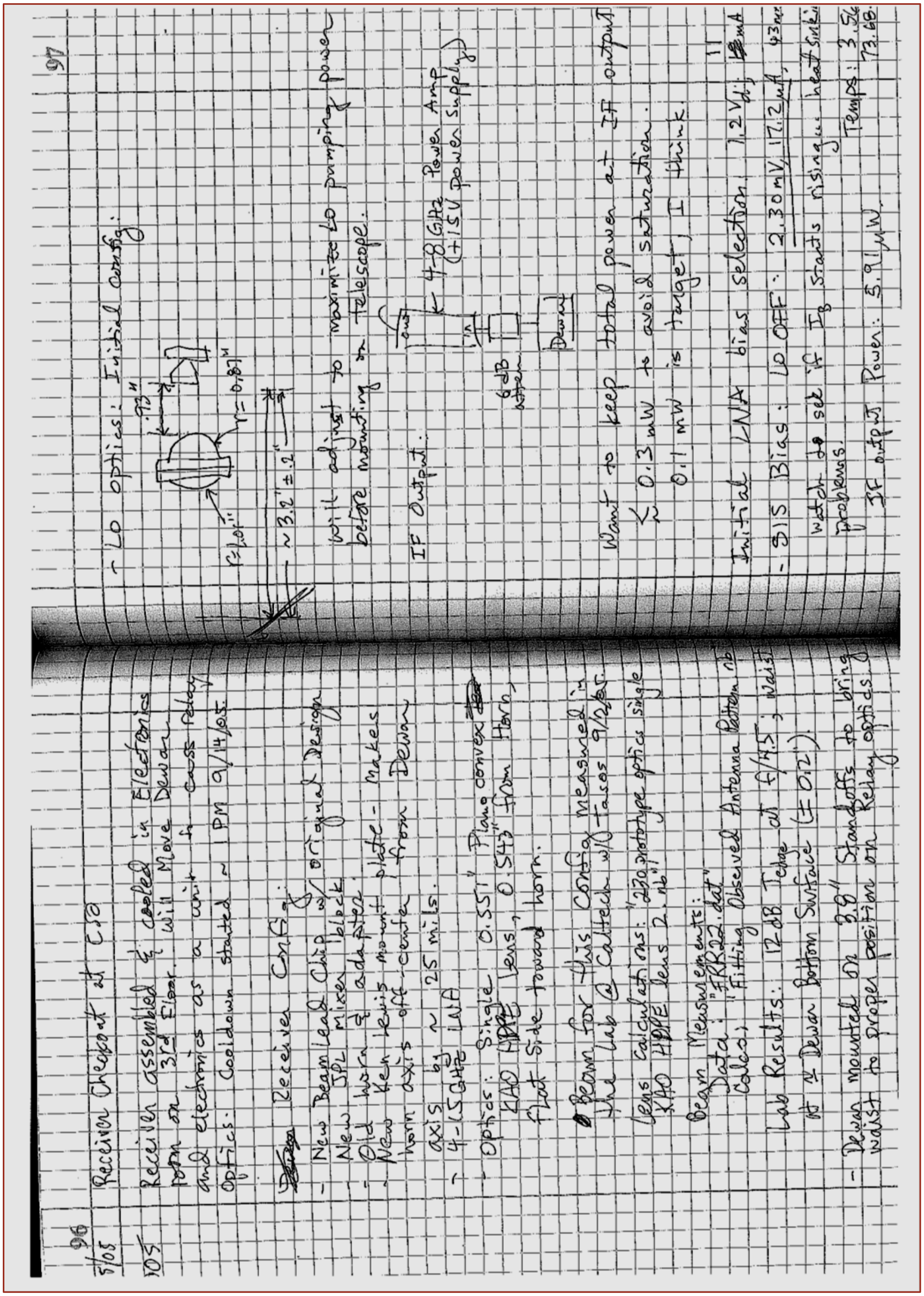
Qualitative comments regarding particular data points (such as some misbehavior of the apparatus, noticeable drift in the equipment readings or settings, how difficult it was to set the conditions or observe the system response, how noisy the readings seemed to be, etc.) will be very important during your analysis as you try to deal with "outliers" in your data set. Selected screen shots of oscilloscope displays or computer data acquisition program displays will usually make your lab notebook record much more complete and understandable.

The results of quick, initial checks of selected data sets should be recorded in your notebook. You should calculate and record "point estimates" of a theory's free parameter values from early data you collect.

Some examples of lab notebook pages

The following several pages include excerpts of in-lab notes recorded mainly during actual research work. They are from various notebooks maintained by the course instructor mostly concerning his graduate research and instrument development efforts. These examples are not meant to show the "ideal" way of keeping lab notes, but they (for the most part) adequately meet the requirements outlined above.

These pages provide an example of how one might describe the setup for a particular data run.



96

9/05 Receiver Checkout at CSO

9/05 Receiver assembled & cooled in Electronics room on 3rd Floor. Will move Dewar and electronics as a unit to Cass Relay Optics. Cooldown started ~ 1 PM 9/14/05.

~~Dewar~~ Receiver Config:

- New Beam Lead Chip w/ original Design
  New JPL mixer block
- Old horn & adapter
- New Ken Lewis mount plate - makes horn axis off center from Dewar axis by ~ 25 mils.
- 4-15 GHz LNA
- Optics: Single 0.551" Plano convex KAO HDPE lens, 0.543" from Horn, flat side toward horn.

Beam for this config measured in the lab @ Caltech w/ Taisos 9/12/05.

Lens calculations: "230 prototype optics single KAO HDPE lens 2. nb"

Beam Measurements:
Data: "FRR22.dat"
Calcs: "Fitting Observed Antenna Pattern nb"

Lab Results: 12 dB T_{edge} at f/4.5; waist at ≈ Dewar Bottom Surface (± 0.2").

- Dewar mounted on 3.8" Standoffs to bring waist to proper position on Relay optics.

97

- LO optics: Initial config:

.73"
r = 1.0"
r = 0.87"
~ 3.2" ± .2"

Will adjust to maximize LO pumping power before mounting on telescope.

IF Output:

out
4-8 GHz Power Amp (+15 V power supply)
in
6 dB atten
Dewar

Want to keep total power at IF output ≲ 0.3 mW to avoid saturation. 0.1 mW is target, I think.

Initial LNA bias selection: 1.2 V_d; 11 mA

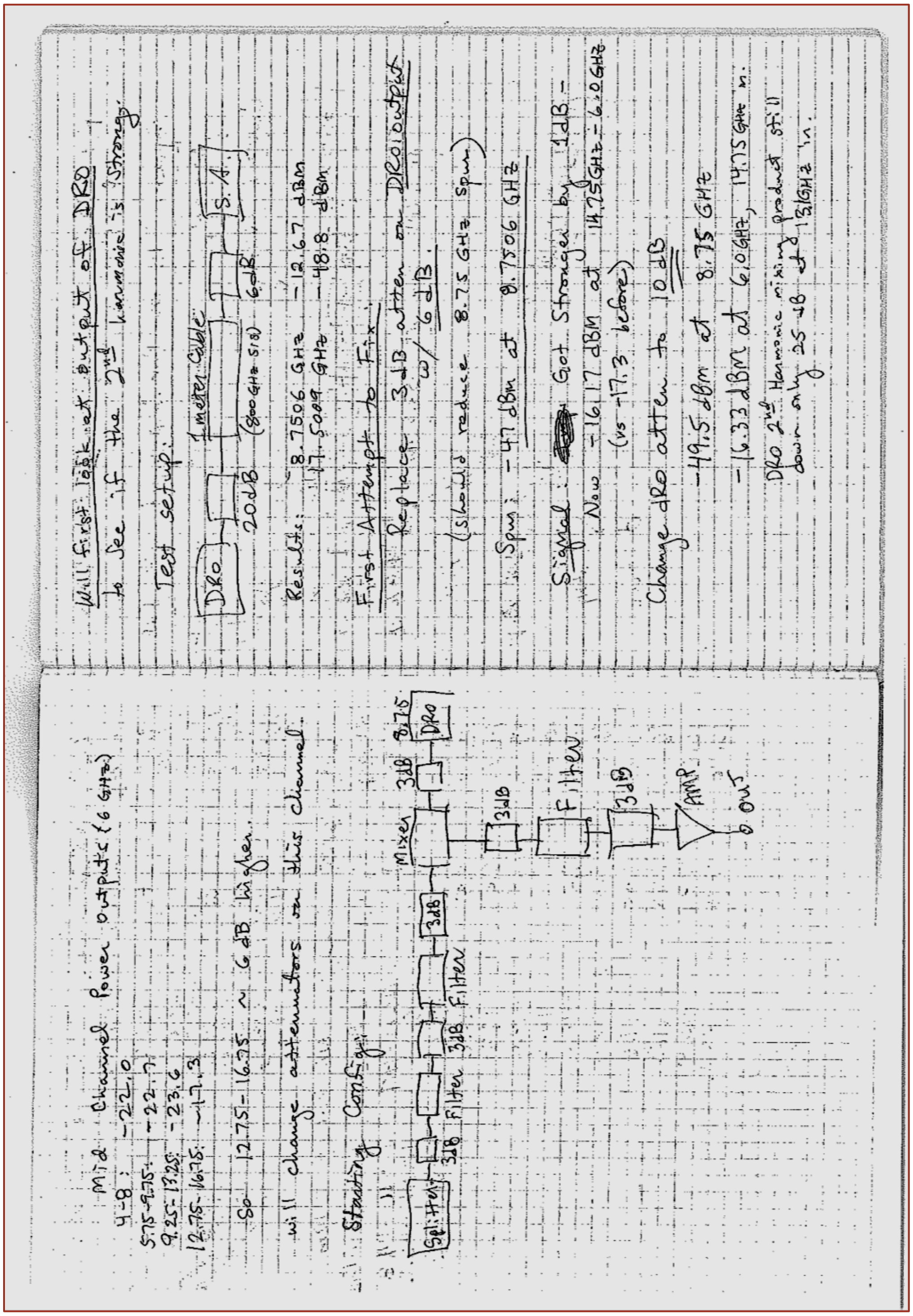
- SIS Bias: LO OFF: 2.30 mV, 17.2 µA, 43 mV

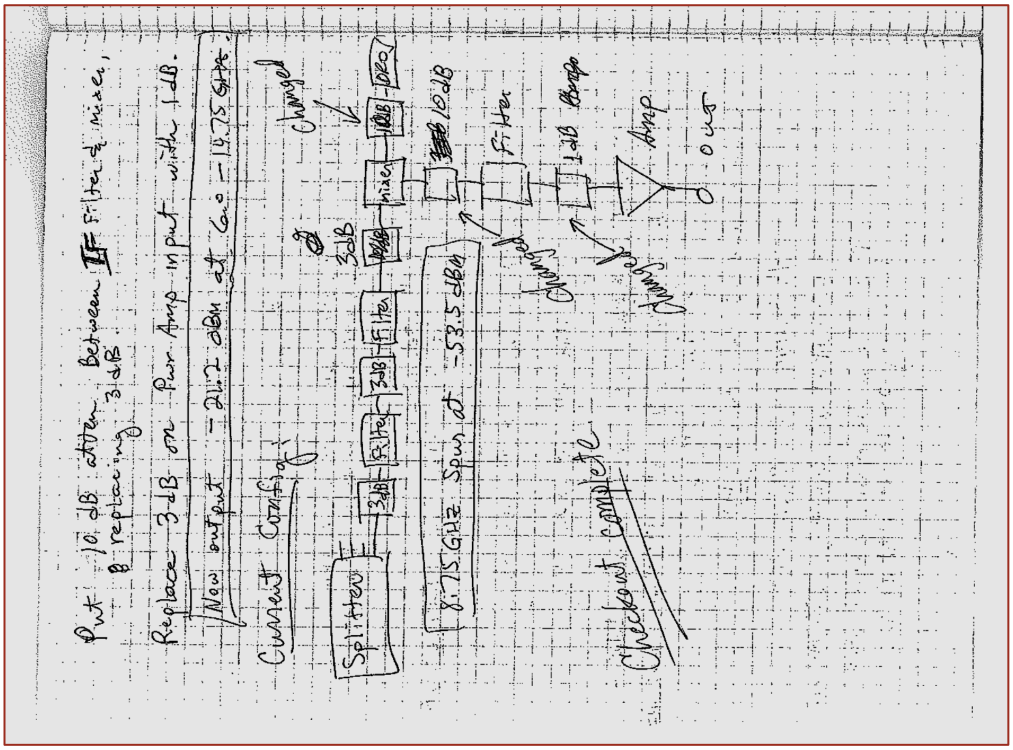
Watch to see if I_B starts rising... heat sinking problems.

Temps: 3.56, 73.68.

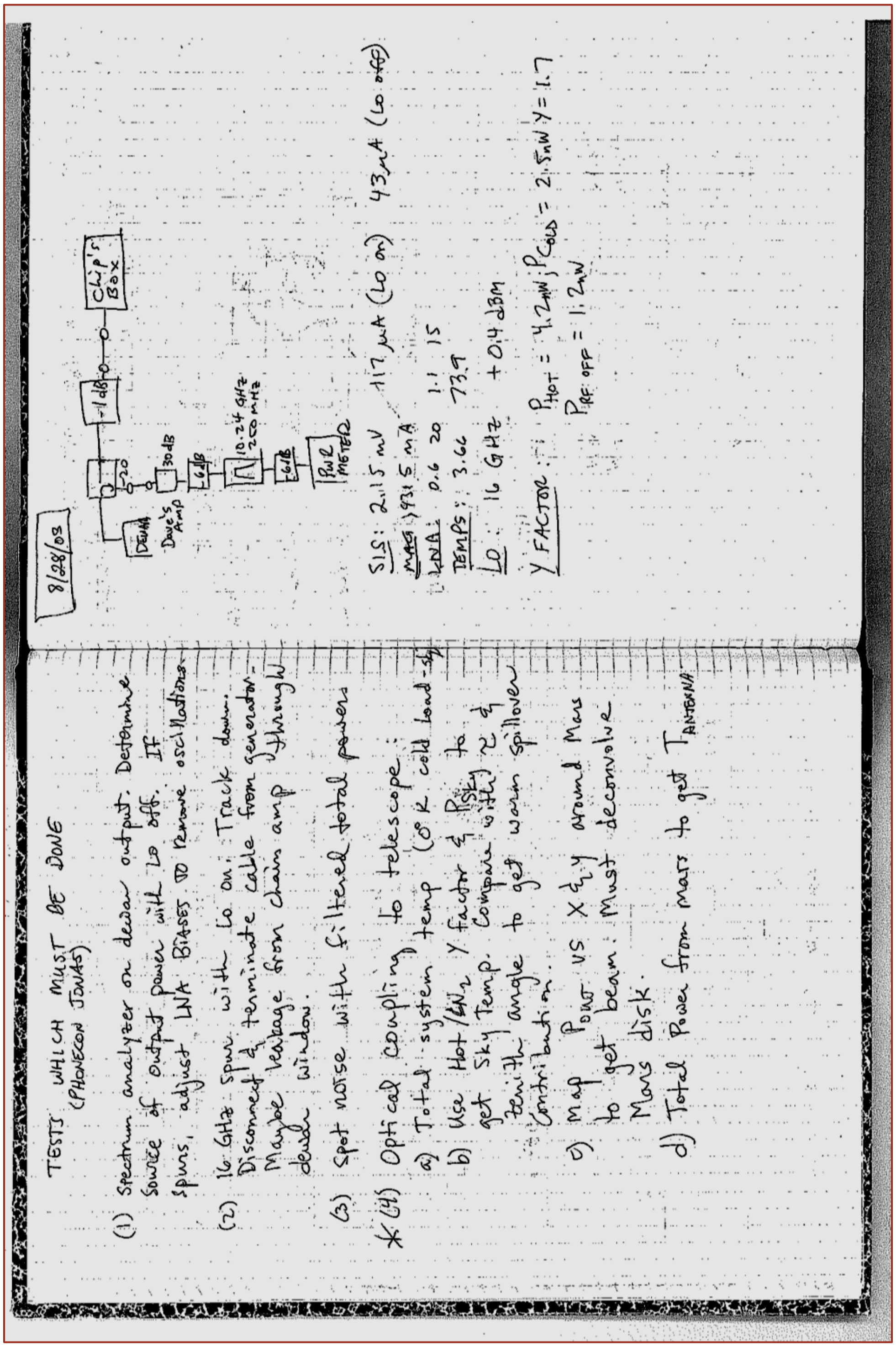
IF output Power: 5.91 µW.

Another example of a setup for a data run. In this case, an initial measurement indicated that a change in the configuration was warranted, so the changes to the setup were described (next page).




Put 10 dB atten. Between IF Filter & mixer,
replacing 3 dB
Replace 3 dB on Pwr Amp input with 1 dB.
Now output -21.2 dBm at 6.0 - 14.75 GHz.
Current Config:
Splitter
3dB
Filter
3dB
Filter
3dB
mixer
10dB
DRO
changed
10 dB
Filter
1 dB
Amp
out
changed
8.25 GHz Spur at -53.5 dBm
Checkout complete

The next several pages document a few hours of tests, measurements, and quick calculations to see how the equipment was working and whether the data were making sense. Data were collected and notes written during a night of setup, testing, and observation at the Caltech Submillimeter Observatory on Mauna Kea in Hawaii—the elevation was 14,000 ft (over 4200 m), and the air was thin (about 60% that at sea level).



TESTS WHICH MUST BE DONE
(PHONECON JONAS)

(1) Spectrum analyzer on dewar output. Determine source of output power with LO off. If spurs, adjust LNA BIASES to remove oscillations.

(2) 16 GHz spur with LO on. Track down. Disconnect & terminate cable from generator. Maybe leakage from chain amp through dewar window.

(3) Spot noise with filtered total powers

* (4) Optical coupling to telescope:

a) Total system temp (0 K cold load sky)

b) Use Hot/LN2 Y factor & P_{SKY} to get sky temp. Compare with τ & zenith angle to get warm spillover contribution.

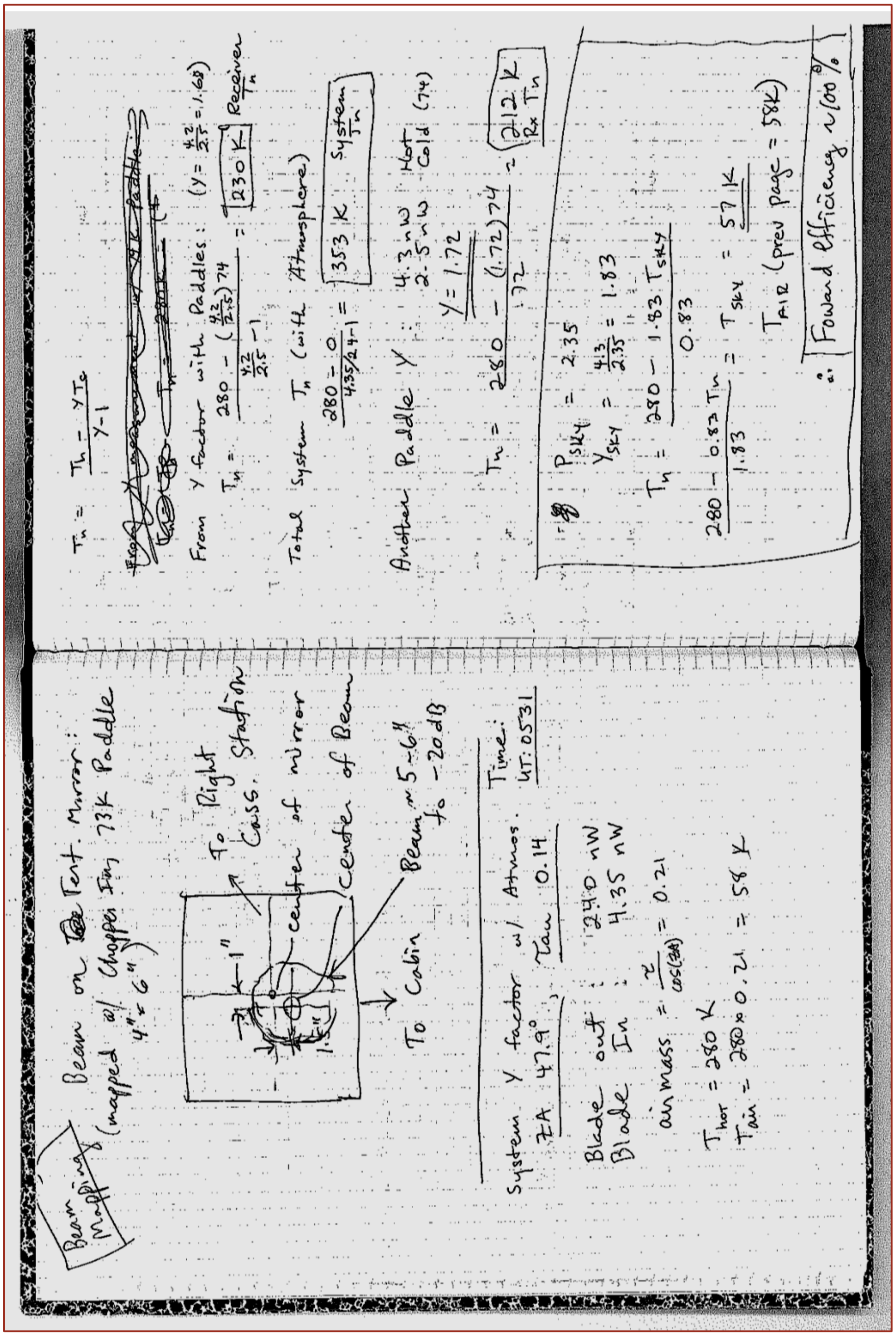
c) map P_{OUT} vs X & Y around Mars to get beam. Must deconvolve Mars disk.

d) Total Power from mars to get $T_{ANTENNA}$

8/28/03

DEWAR
Dave's Amp
-20
30dB
6dB
10.24 GHz 250 MHz
6dB
PWR METER
-1dB
Chip's BOX

SIS: 2.15 mV 117 μA (LO on) 43 μA (LO off)
MAG: 931.5 mA
LNA: 0.6 20 1.1 15
TEMPS: 3.66 73.9
LO: 16 GHz +0.4 dBM
Y FACTOR: P_{HOT} = 4.2 nW; P_{COLD} = 2.5 nW Y = 1.7
$P_{RF\ OFF}$ = 1.2 nW



Beam Mapping

Beam on Test. Mirror:
(mapped w/ Chopper Fin; 73K Paddle
4" × 6")

System Y factor w/ Atmos.
ZA 47.9°, Tau 0.14

Time:
UT: 0531

Blade out : 24.0 nW
Blade In : 4.35 nW

air mass = $\frac{\tau}{\cos(ZA)}$ = 0.21

T_{hot} = 280 K
T_{air} = 280 × 0.21 = 58 K

$T_n = \frac{T_h - Y T_c}{Y - 1}$

~~From Y measurement w/ 73K Paddle~~

~~T_n = 280 K~~

From Y factor with Paddles: $(Y = \frac{4.2}{2.5} = 1.68)$

$T_n = \frac{280 - (\frac{4.2}{2.5})74}{\frac{4.2}{2.5} - 1}$ = **230 K** Receiver T_n

Total System T_n (with Atmosphere)

$\frac{280 - 0}{4.35/24 - 1}$ = **353 K** System T_n

Another Paddle Y : 4.3 nW Hot
2.5 nW Cold (74)

Y = 1.72

$T_n = \frac{280 - (1.72)74}{.72}$ ≈ **212 K** Rx T_n

P_{SKY} = 2.35

$Y_{SKY} = \frac{4.3}{2.35}$ = 1.83

$T_n = \frac{280 - 1.83\, T_{SKY}}{0.83}$

$\frac{280 - 0.83\, T_n}{1.83} = T_{SKY}$ = 57 K

T_{AIR} (prev page = 58K)

∴ Foward Efficiency ~100%

Looked ~~two~~ at two problems with spectrum analyzer on ~~total~~ power output.

(1.) 16 GHz spur with LO on,

(a) Spur goes away when generator disconnected from LO chain.

(b) spur goes away when <u>LO Horn</u> blocked.

Hypothesis – Coupling between the two amps in LO chain.

(2) Large power output with no LO.
Nothing unusual in spectrum analyzer (may not be sensitive enough)
Except for a broad (~ 0.5 GHz) double-peak at ~ 23 GHz. (height ~ -70 dBm (4 MHz channels))

(a) Peak unaffected by SIS bias.

(b) Peak unaffected by LO power

(c) Peak greatly affected by ~~~~ 1ST LNA Bias. Was gone with 0.4V 20 mA.

(d) No IF output power from receiver with above bias. Reset to 0.6V 20 mA.

Reconnected total power meter as diagrammed previously.

Pointing & Beam Map on Mars.

– Blank sky $P_{HOT} = 3.6$ nW; $P_{sky} = 2.0$ nW $Y_{sky} = 1.8$

UTC 0659 Az +120° ZA + 62.5 on MARS.

$P_{sky} = 2.04$ nW. OFFSET to 0 here.

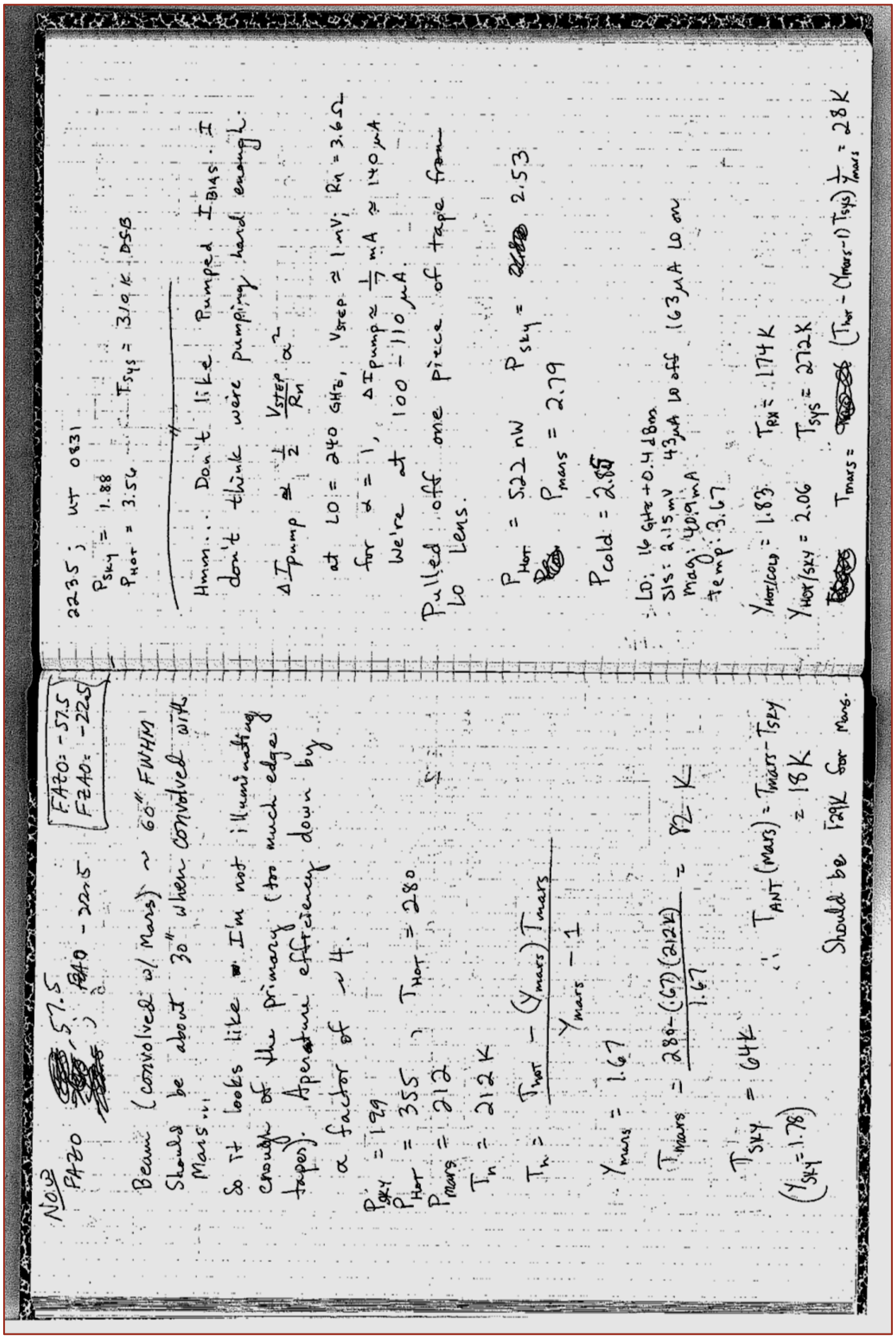
To: azo 0 + 0.11 nW (sees mars...)

Rough Raster on Mars with Pointing & Focus set as before.

15″ steps in AZ & ZA ± 60″ total

ZA \ Az	-60	-45	-30	-15	0	15	30	45	60
+60	202	2.01	200	200	199	199	200	198	200
+45	200	198	199	200	200	201	199	199	198
+30	199	199	202	203	203	203	200	200	198
+15	200	200	203	205	211	208	200	199	199
0	198	200	206	212	212	209	202	200	199
-15	199	200	205	210	208	207	201	200	199
-30	200	201	202	204	204	202	200	198	196
-45	199	199	201	203	202	198	199	199	198
-60	197	199	199	199	199	198	197	197	197

FAZO -52.5 Focus -0.9
FZAO -22.5 X_Pos -10.3



Now
FAZO -57.5 ; FAO -22.5 | FAZO: -57.5, FZAO: -22.5

Beam (convolved w/ Mars) ~ 60" FWHM
Should be about 30" when convolved with Mars...
So it looks like I'm not illuminating enough of the primary (too much edge taper). Aperature efficiency down by a factor of ~4.

$P_{SKY} = 199$
$P_{HOT} = 355$, $T_{HOT} = 280$
$P_{mars} = 212$
$T_n = 212$ K

$$T_n = \frac{T_{hot} - (Y_{mars}) T_{mars}}{Y_{mars} - 1}$$

$Y_{mars} = 1.67$

$$T_{mars} = \frac{280 - (.67)(212K)}{1.67} \approx 82\ K$$

$T_{SKY} = 64K$ $(Y_{SKY} = 1.78)$

$\therefore T_{ANT}(mars) = T_{mars} - T_{SKY} \approx 18K$

Should be 29K for Mars.

2235 ; UT 0831
$P_{SKY} = 1.88$
$P_{HOT} = 3.56$ $T_{sys} = 310K$ DSB

Hmm... Don't like Pumped I_{BIAS}. I don't think were pumping hard enough.

$$\Delta I_{pump} \cong \frac{1}{2} \frac{V_{STEP}}{R_n} \alpha^2$$

at LO = 240 GHz, $V_{STEP} \approx 1$ mV; $R_n = 3.6\,\Omega$
for $\alpha = 1$, $\Delta I_{pump} \approx \frac{1}{7}$ mA $\approx 140\,\mu A$
We're at 100 – 110 μA.

Pulled off one piece of tape from LO Lens.

$P_{Hot} = 5.22$ nW $P_{sky} = 2.53$
$P_{mars} = 2.79$
$P_{cold} = 2.85$

LO: 16 GHz +0.4 dBm
SIS: 2.15 mV 43 μA LO off 163 μA LO on
mag: 40.9 mA
temp: 3.67

$Y_{HOT/COLD} = 1.83$ $T_{RX} = 174K$
$Y_{HOT/SKY} = 2.06$ $T_{sys} = 272K$
$T_{mars} = (T_{hot} - (Y_{mars} - 1) T_{sys}) \frac{1}{Y_{mars}} = 28K$