BPM

Design Note #2
11/4/81

Wire Measurement of Position Detector Performance

R.C. Webber K.C. Cahill, Q Kerns R. Shafer

Attached are 5 plots of detector output db ratio vs. wire position for a .004" tungsten wire excited with a 53 MHz current. The excitation is via a cavity designed & built by Q. Kerns. Power can be made to flow in either direction along wire. The wire is supported by pulley arrangements which apply constant tension, and can be moved roughly ± 0.5" in x and y.

The observed slope in Figs 1-3 is about 0.65 db/mm. This is slightly lower than the value reported in IEEE/NS, vol NS 28 #3 page 2290 (1981) (0.67 db/mm). However, careful sighting along plots indicate that the slope might be increasing near the ends. The .67db/mm is for ± 1 inch motion, while the .65 db/mm is for ± 0.5 inch motion.

The measurement for y = +.5" displacement yields .70 db/mm (Figure 5). This would imply a response function

$$x = \frac{1}{.65}\left(1 - \frac{y^2}{a}\right)\left(\frac{A}{B}\right)_{db}$$

where $a \sim 2300 \pm 20\%$

(we have been using 2830)

The detector shows a slight sensitivity to a y scan at x=0.

this can be interpreted as an x-y coupling due to detector rotational misalignment. the slope of .04 db/mm corresponds to a $\Delta\theta$ of about

$$\Delta\theta \sim \frac{.04}{.65} = 60 \text{ mrad } (\sim 3.5^\circ)$$

At ± 25mm, this corresponds to an error in x of about

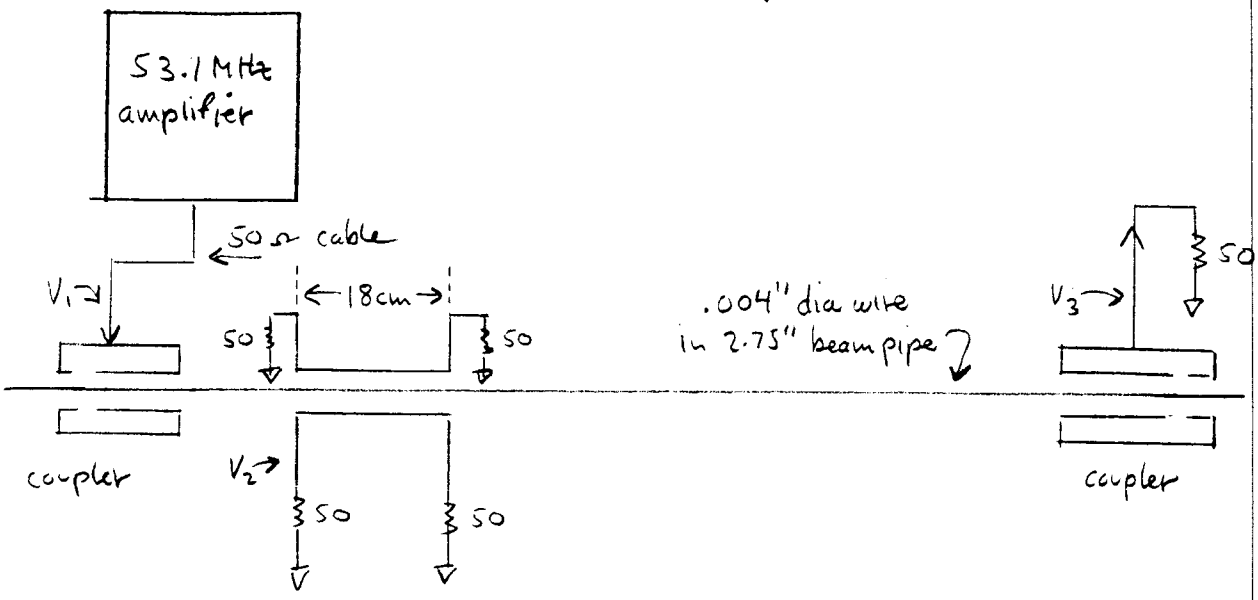
$$.04\frac{db}{mm} \times 25mm \times \frac{1mm}{.67db} = 1.49 \text{ mm.}$$

It is apparent that this is too large by roughly a factor of 5. Hence the angular misalignment must be held to within ± 12 mrad. This will hold the maximum error to less than ± 0.3 mm.

Figure 6 shows the measured detector sensitivity for a centered wire. It is a plot of voltage of the detector output vs the voltage input to the tungsten wire (at 50 Ω point). The curve shows the db ratio to be about -33 ± 1 db.

Table I presents an approximate calculation of this ratio, yielding -34 ± 2 db. The detector sensitivity appears to be ≈ 1 db higher than calculated, which may be due to the fact that the % of image charges induced on plate may be larger than the $\frac{110^\circ}{360^\circ} = 31\%$ geometrical subtended angle. To increase the sensitivity by 1.2 db, the subtended angle would have to be increased by about 15%.

Table I Calculation of detector coupling



Calculation of detector coupling $\left(\frac{V_2}{V_1}\right)_{db}$.

1. Coupler efficiency: Power loss from V_1 to V_3 is about 2.6 db. 0.6 db est in wire. ∴ ~ 1 db in each coupler } $-1 \pm .5$ db

2. $Z_{wire} = 60 \ln \frac{2.75}{.004} = 392$ ohms

attenuation of current $= \left(\sqrt{\frac{50}{392}}\right)_{db} =$ -8.9 ± 1.0 db

3. Detector coupling:

$\left(\frac{I_{output}}{I_{wire}}\right)_{db} = \left(\frac{110^\circ}{360^\circ} \sin \omega t_0\right)_{db} =$ -24.3 ± 1.0 db

$\omega = 2\pi \times 53 \text{ MHz} = 334 \times 10^6 \text{ sec}^{-1}$

$t_0 = 18\text{cm} / 30\text{cm per nsec} = .6 \text{ nsec}$

total -34.2 ± 2 db

DOUBLER BEAM DETECTOR OUTPUT

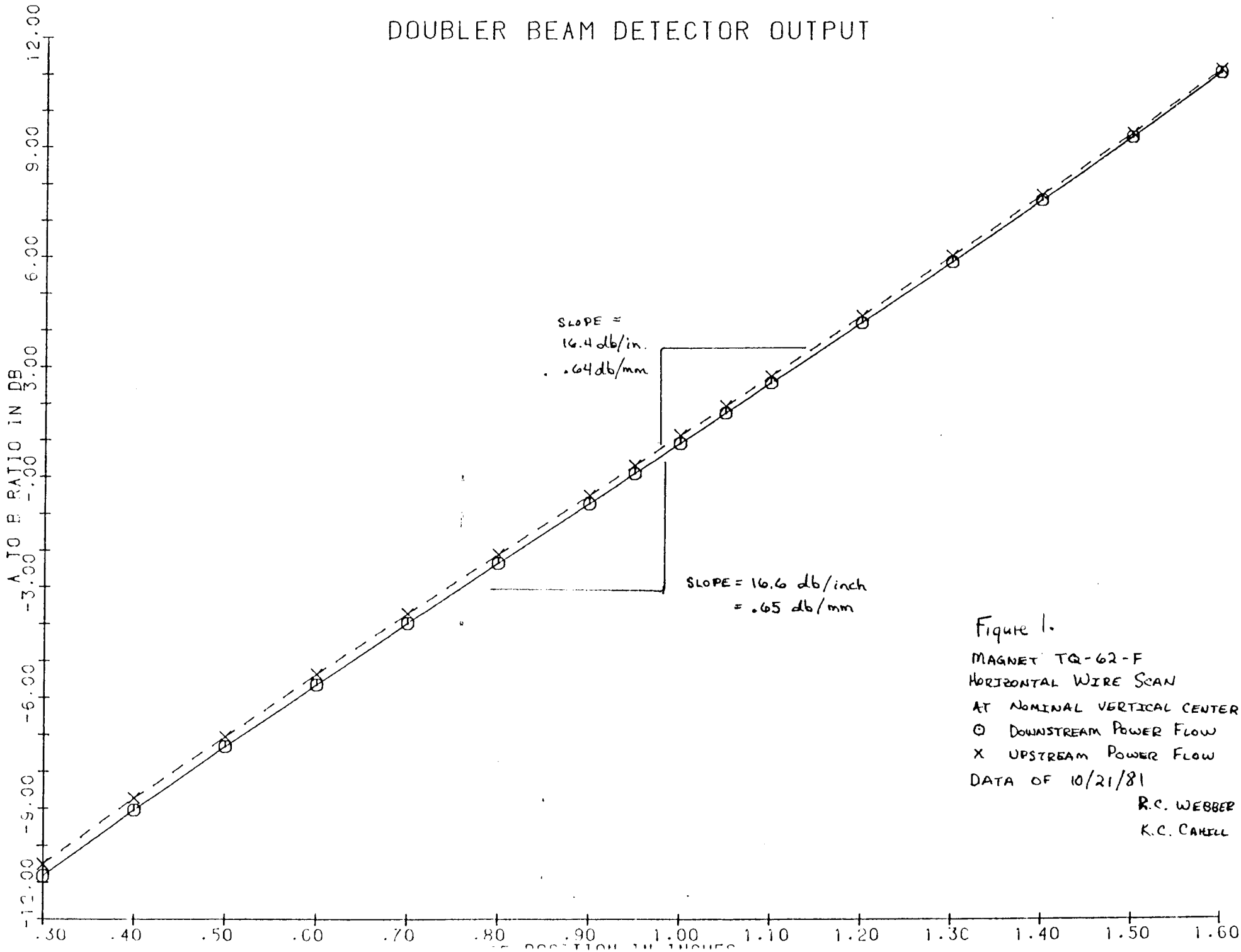


Figure 1.

MAGNET TQ-62-F
HORIZONTAL WIRE SCAN
AT NOMINAL VERTICAL CENTER
⊙ DOWNSTREAM POWER FLOW
X UPSTREAM POWER FLOW
DATA OF 10/21/81

R.C. WEBBER
K.C. CAHILL

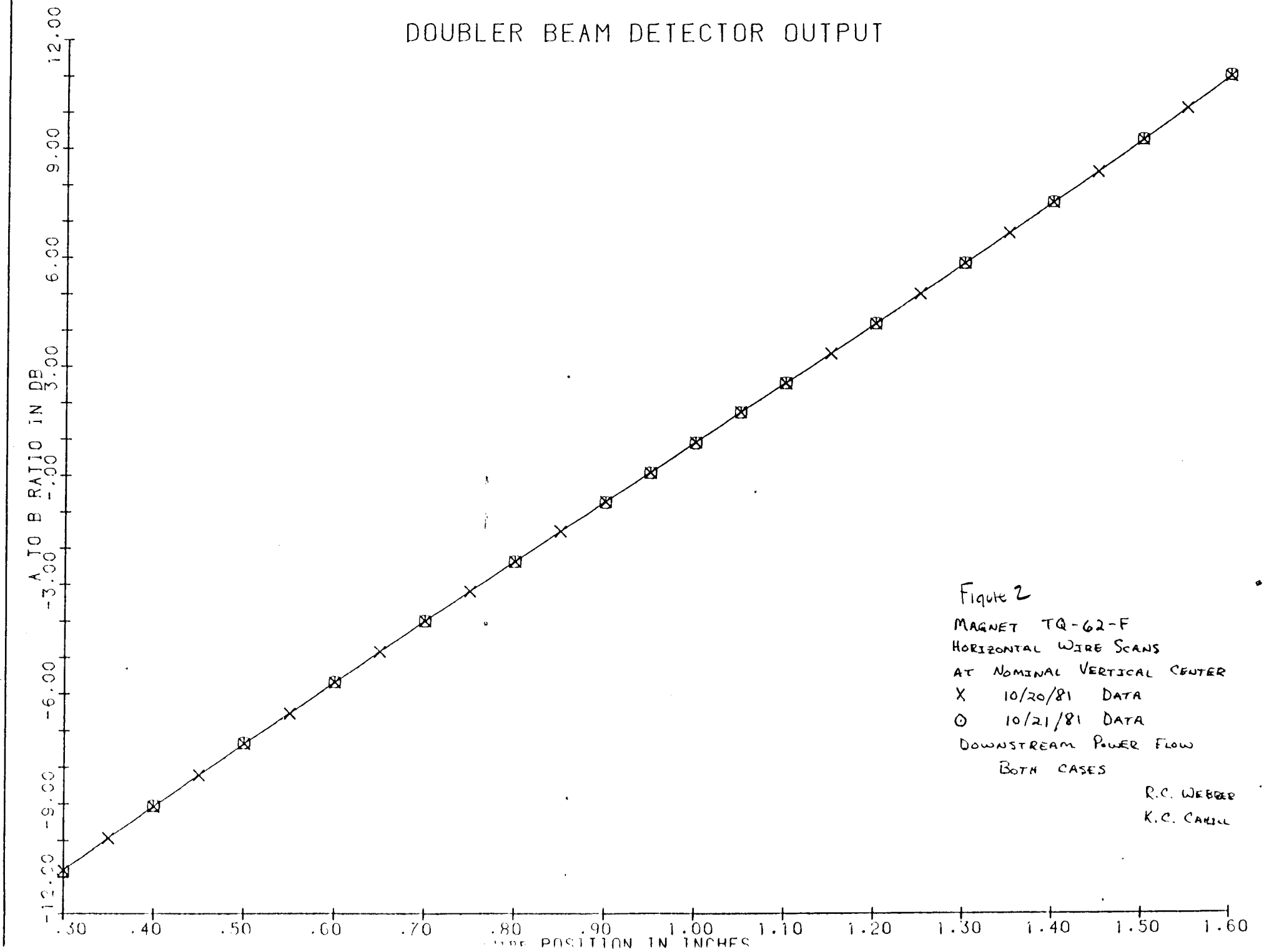


Figure 2

MAGNET TQ-62-F
HORIZONTAL WIRE SCANS
AT NOMINAL VERTICAL CENTER
X 10/20/81 DATA
⊙ 10/21/81 DATA
DOWNSTREAM POWER FLOW
BOTH CASES

R.C. WEBBER
K.C. CAHILL

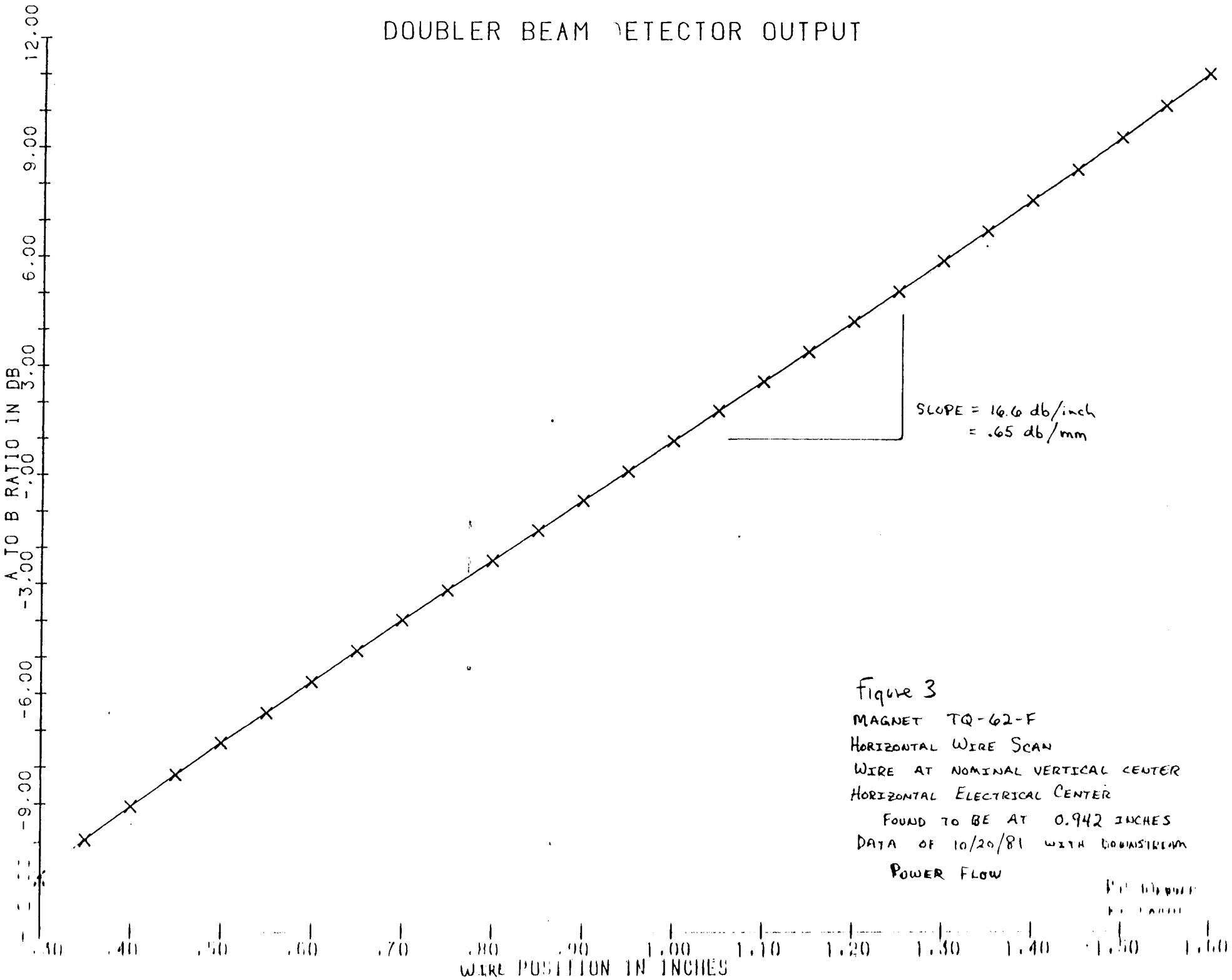
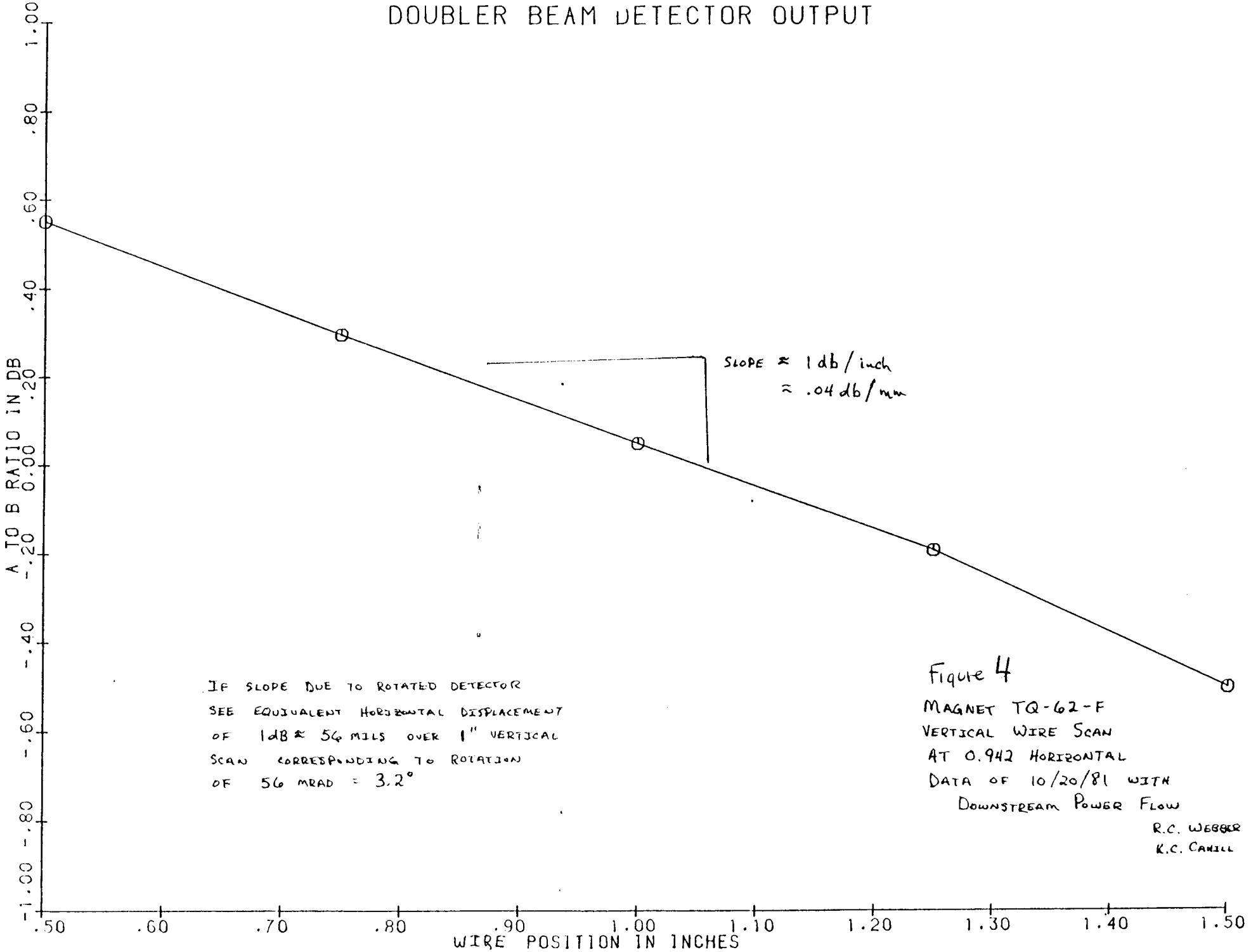


Figure 3
MAGNET TQ-62-F
HORIZONTAL WIRE SCAN
WIRE AT NOMINAL VERTICAL CENTER
HORIZONTAL ELECTRICAL CENTER
FOUND TO BE AT 0.942 INCHES
DATA OF 10/20/81 WITH DOWNSTREAM
POWER FLOW

DOUBLER BEAM DETECTOR OUTPUT



IF SLOPE DUE TO ROTATED DETECTOR
SEE EQUIVALENT HORIZONTAL DISPLACEMENT
OF 1dB ≈ 56 MILS OVER 1" VERTICAL
SCAN CORRESPONDING TO ROTATION
OF 56 MRAD = 3.2°

Figure 4

MAGNET TQ-62-F
VERTICAL WIRE SCAN
AT 0.942 HORIZONTAL
DATA OF 10/20/81 WITH
DOWNSTREAM POWER FLOW

R.C. WEBBER
K.C. CAHILL

DOUBLER BEAM DETECTOR OUTPUT

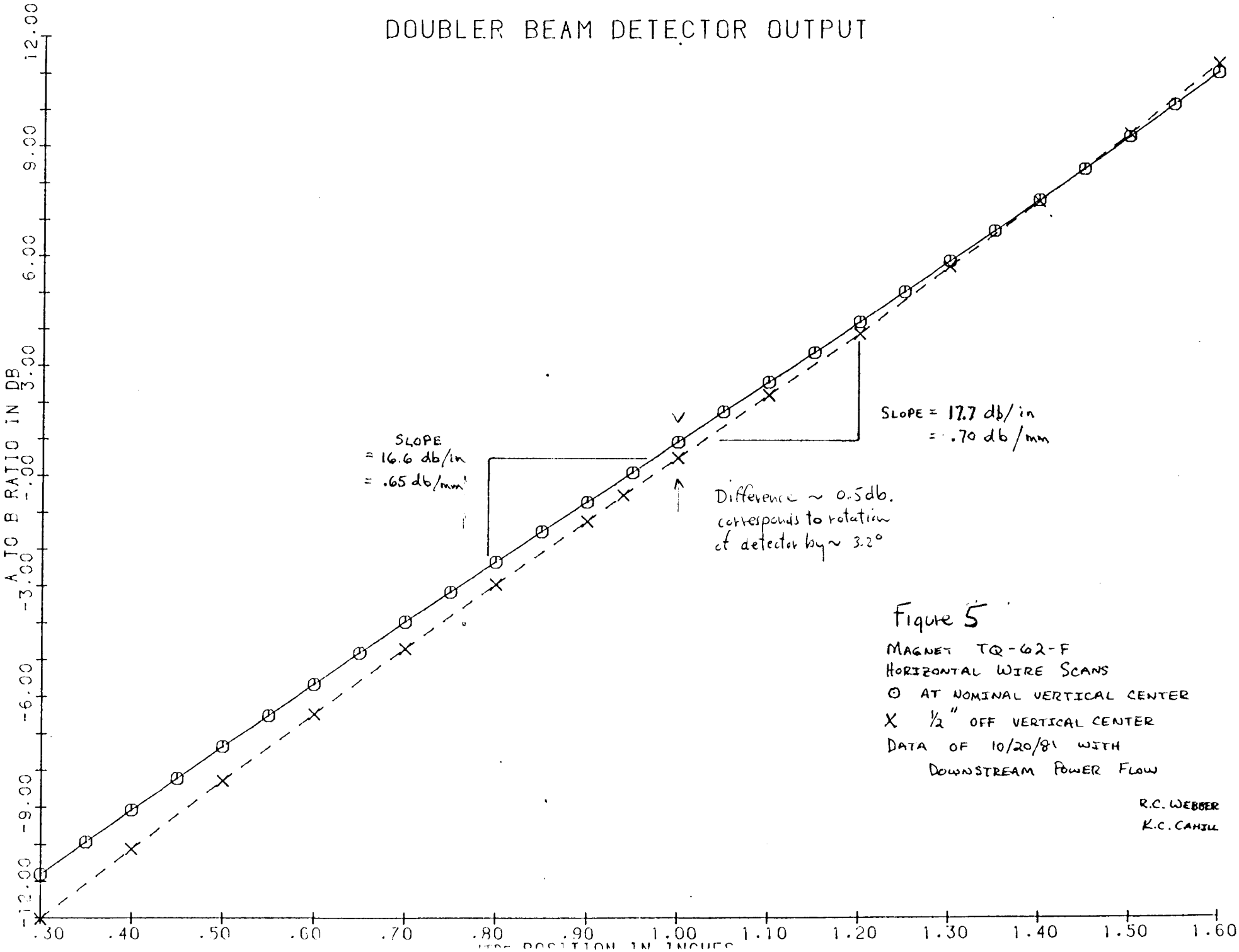


Figure 5

MAGNET TQ-62-F
HORIZONTAL WIRE SCANS
⊙ AT NOMINAL VERTICAL CENTER
X ½" OFF VERTICAL CENTER
DATA OF 10/20/81 WITH DOWNSTREAM POWER FLOW

R.C. WEBBER
K.C. CAHILL

K·Σ SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 6210

Power output (dbw)

10

0

-10

-20

-30

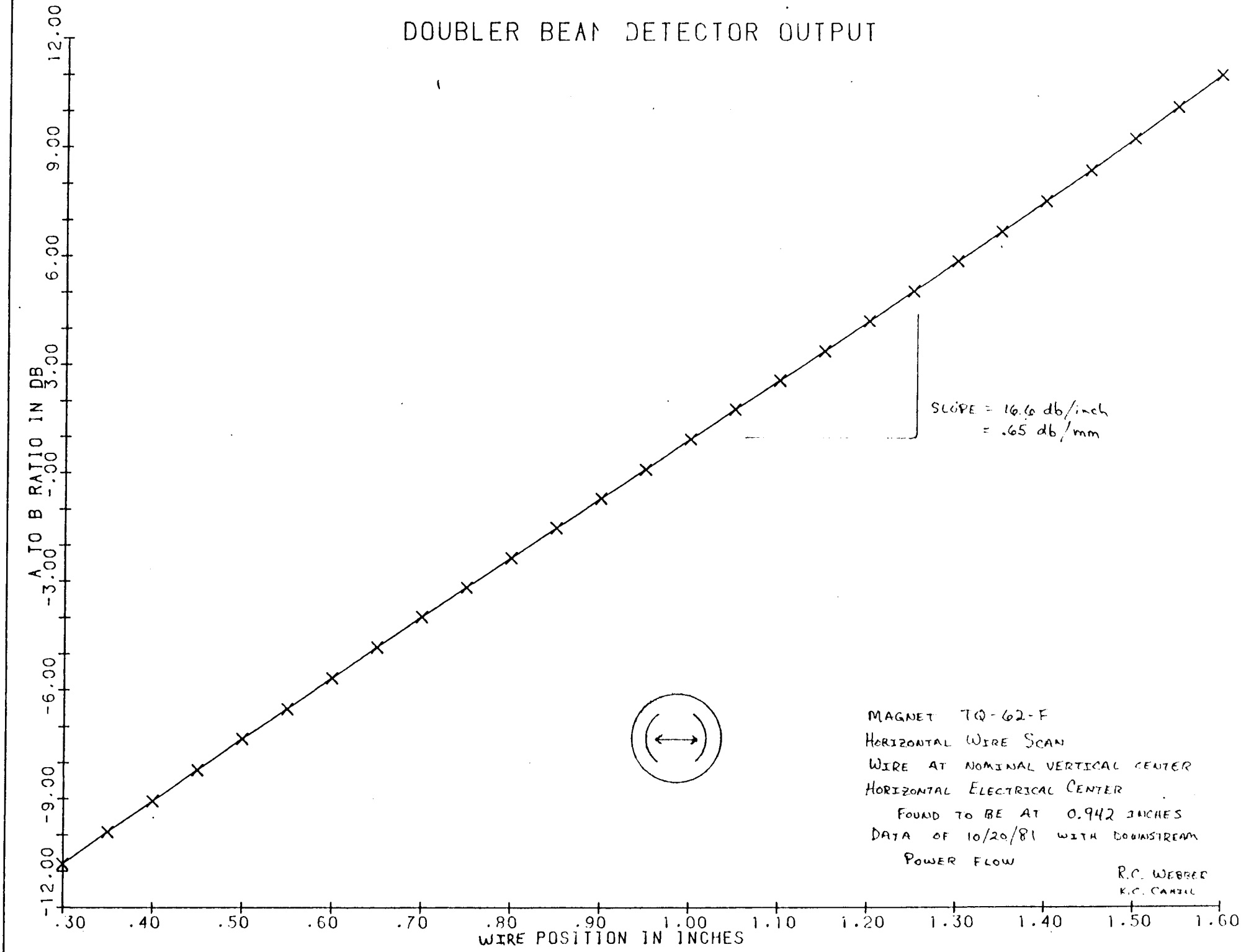
-30 db

-33 db

-36 db

Measured by Q Ferrel, B6 Lockheed

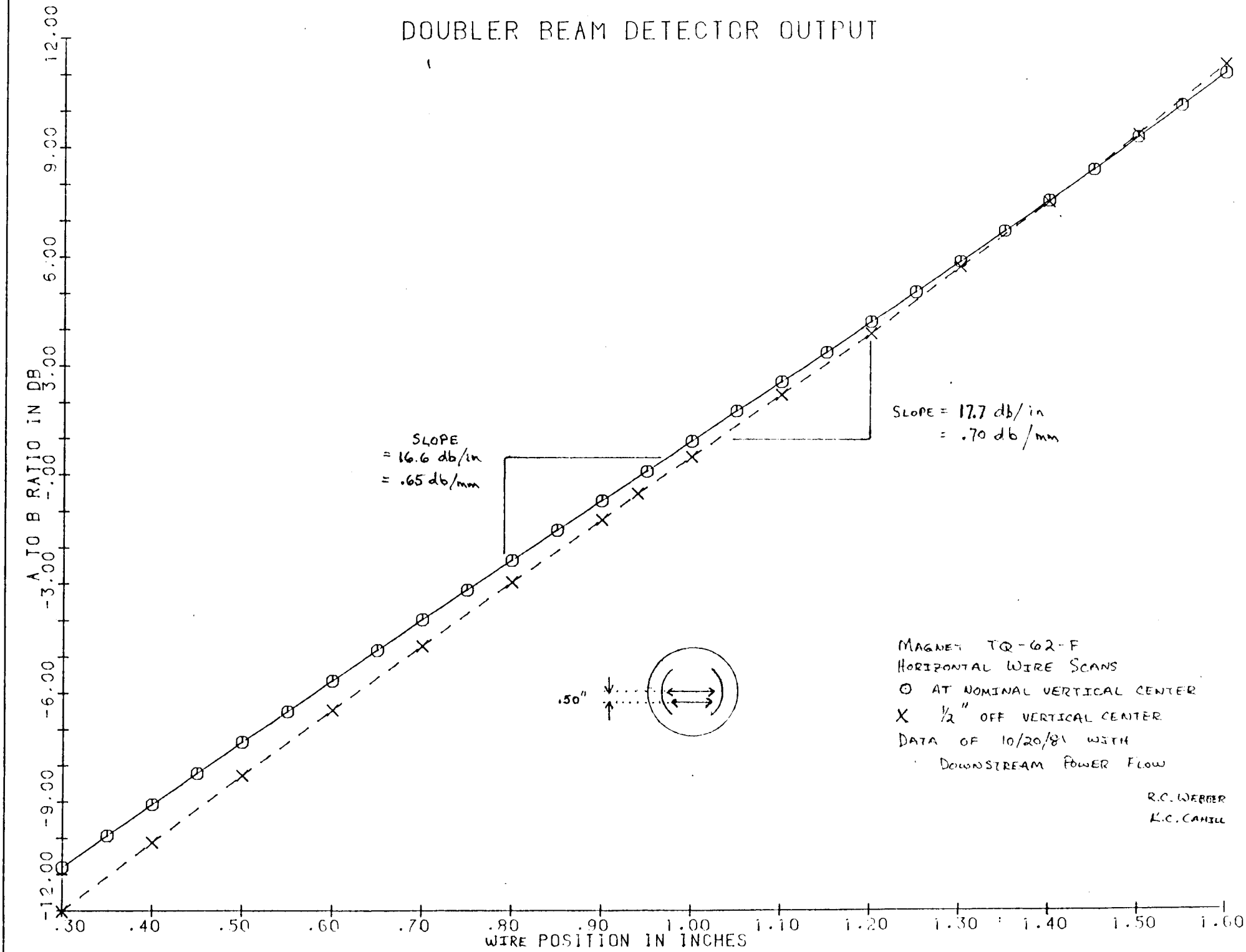
DOUBLER BEAM DETECTOR OUTPUT



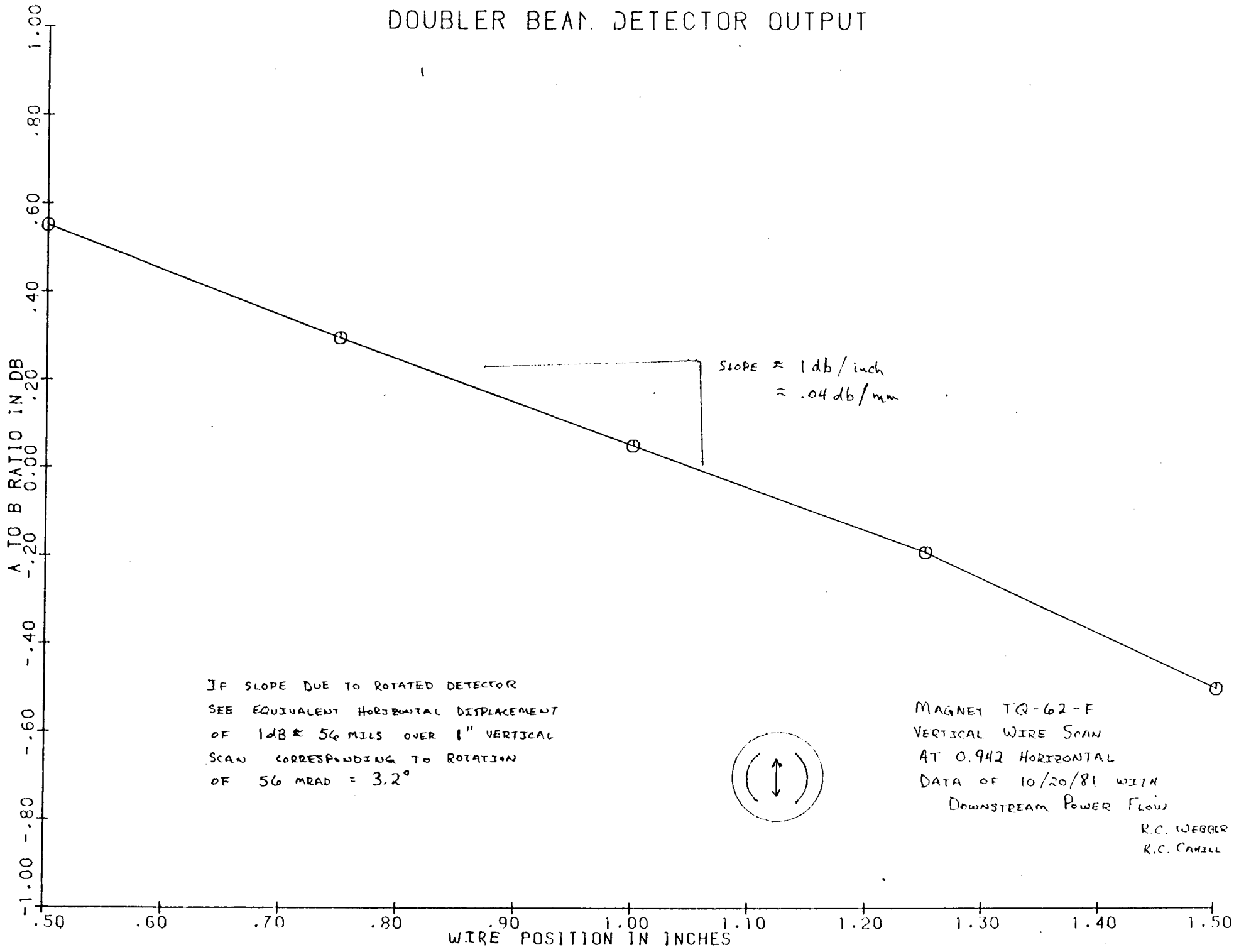
MAGNET TQ-62-F
HORIZONTAL WIRE SCAN
WIRE AT NOMINAL VERTICAL CENTER
HORIZONTAL ELECTRICAL CENTER
FOUND TO BE AT 0.942 INCHES
DATA OF 10/20/81 WITH DOWNSTREAM
POWER FLOW

R.C. WEBBER
K.C. CAHILL

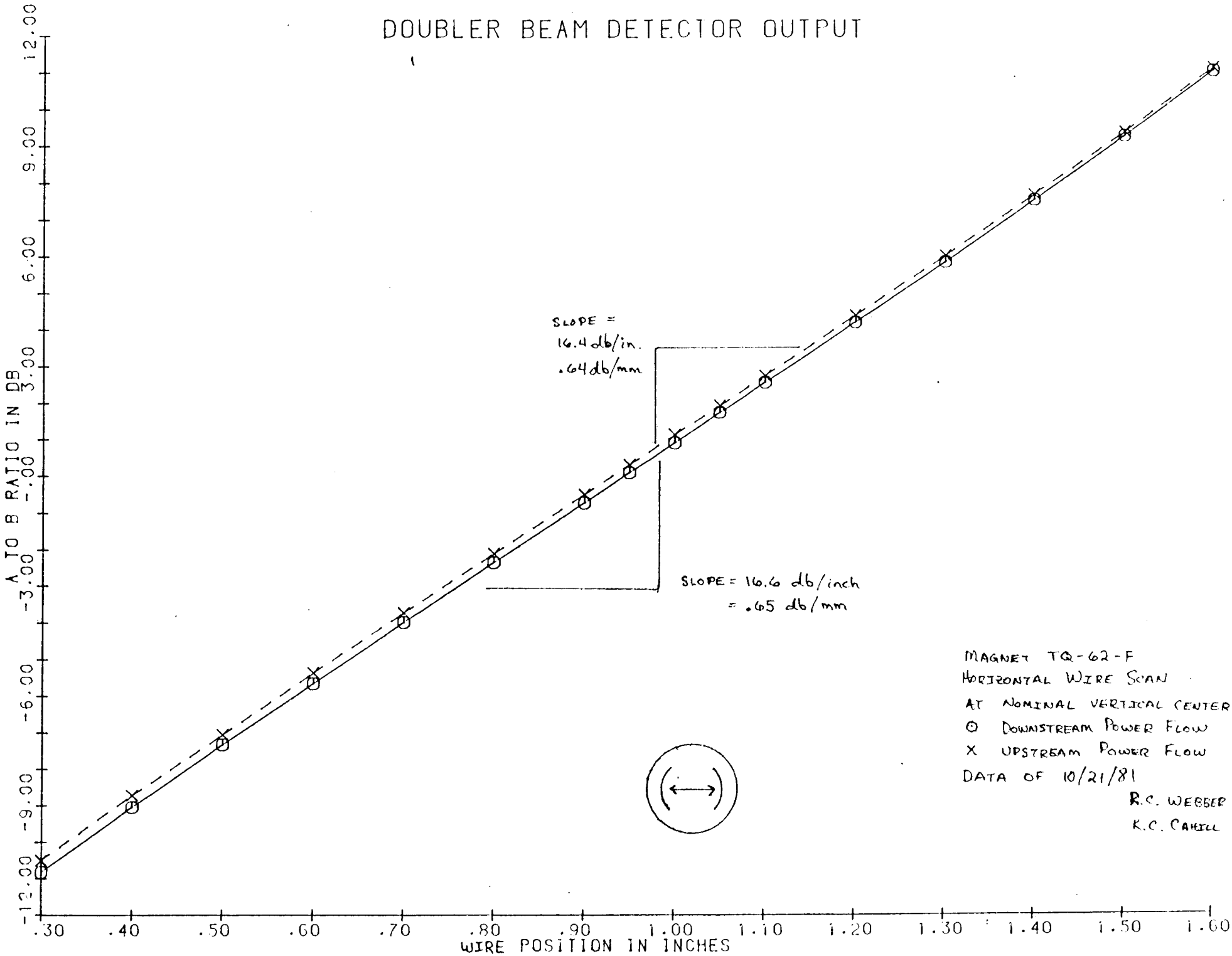
DOUBLER BEAM DETECTOR OUTPUT



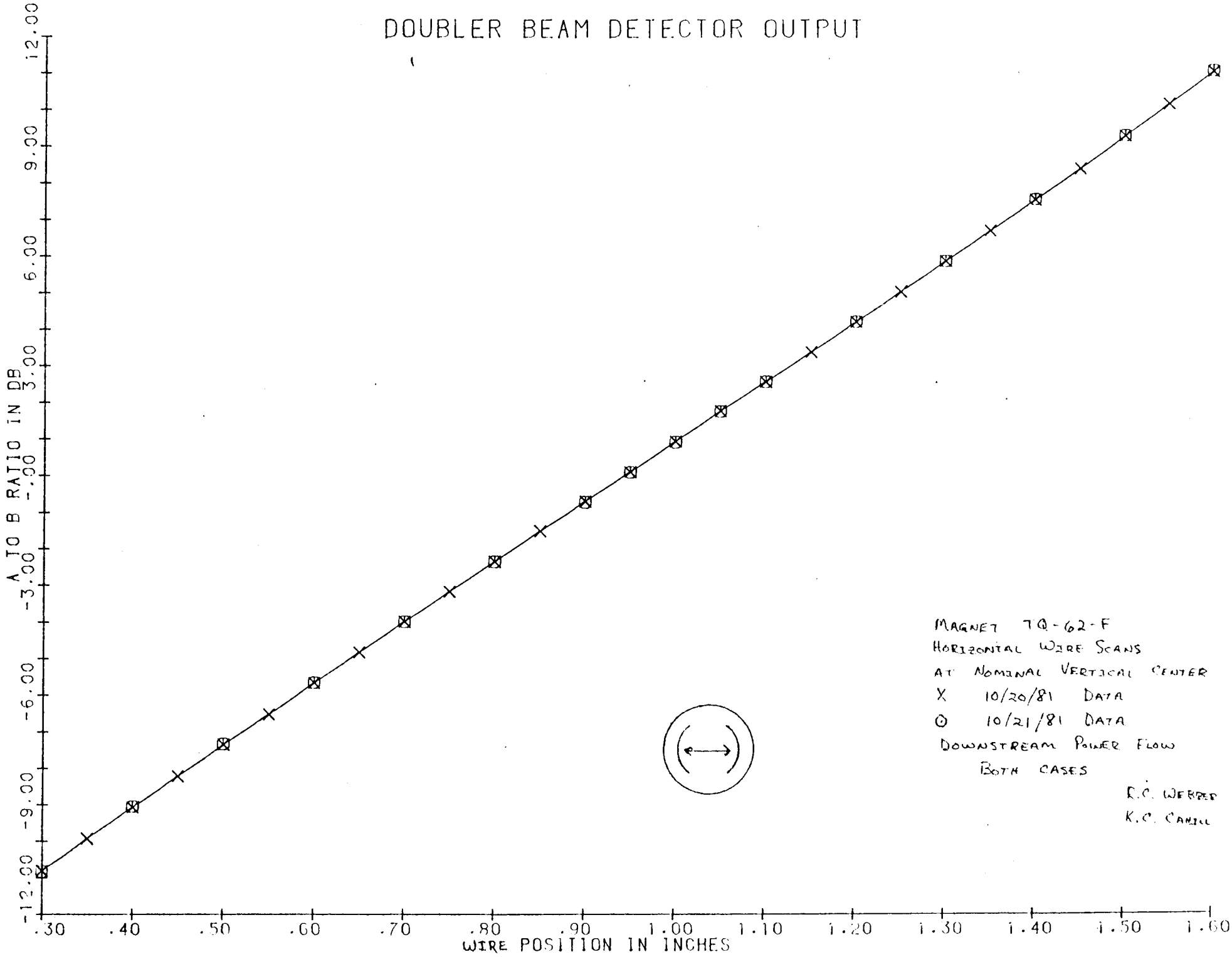
DOUBLER BEAM DETECTOR OUTPUT



DOUBLER BEAM DETECTOR OUTPUT



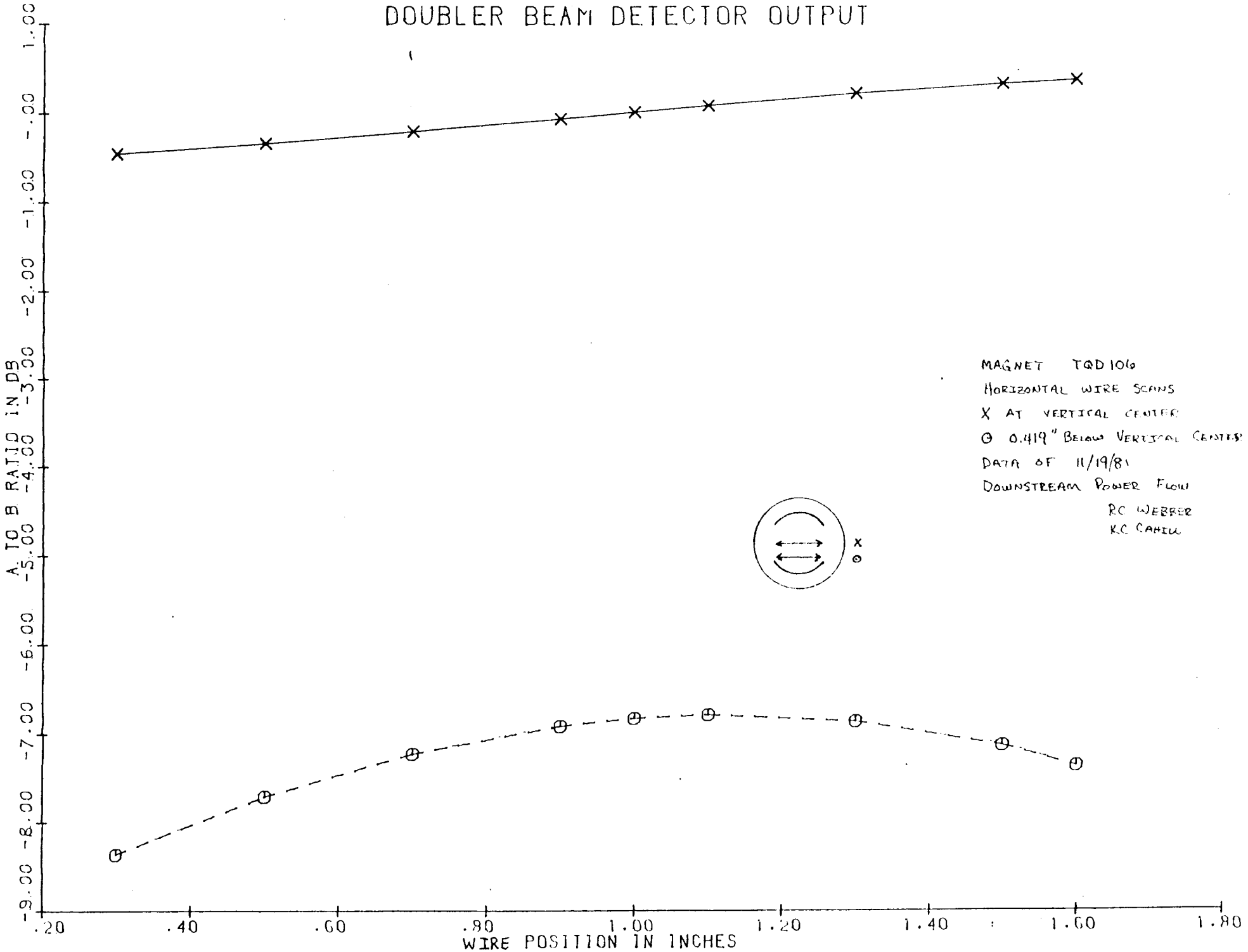
DOUBLER BEAM DETECTOR OUTPUT



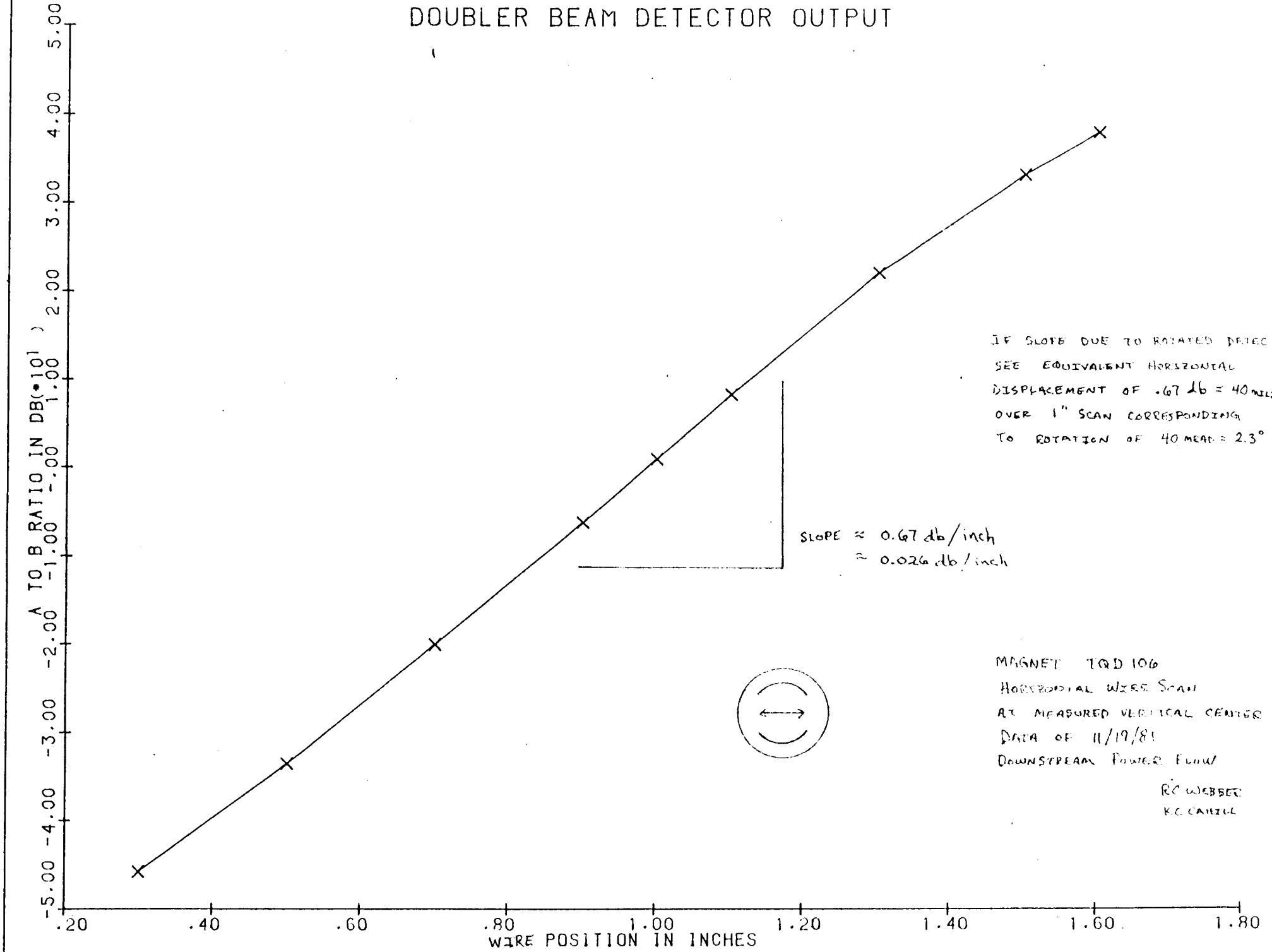
MAGNET TQ-62-F
HORIZONTAL WIRE SCANS
AT NOMINAL VERTICAL CENTER
X 10/20/81 DATA
⊙ 10/21/81 DATA
DOWNSTREAM POWER FLOW
BOTH CASES

R.C. WERTZ
K.C. CAHILL

DOUBLER BEAM DETECTOR OUTPUT



DOUBLER BEAM DETECTOR OUTPUT

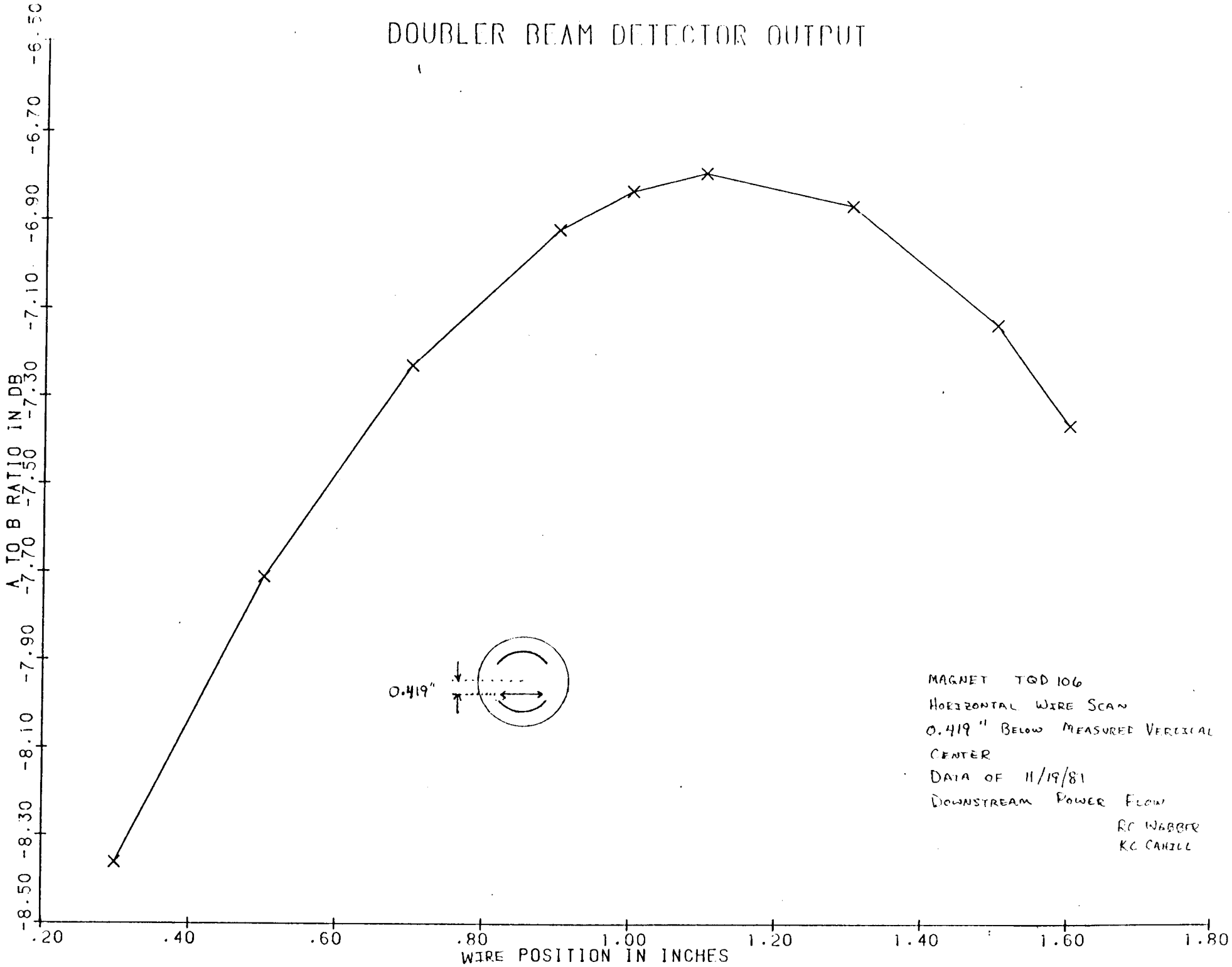


IF SLOPE DUE TO ROTATED DETECTOR
SEE EQUIVALENT HORIZONTAL
DISPLACEMENT OF .67 db = 40 MILS
OVER 1" SCAN CORRESPONDING
TO ROTATION OF 40 MRAD = 2.3°

MAGNET TQD 106
HORIZONTAL WIRE SCAN
AT MEASURED VERTICAL CENTER
DATA OF 11/19/81
DOWNSTREAM POWER FLOW

RC WEBBER
K.C. CAHILL

DOUBLER BEAM DETECTOR OUTPUT



MAGNET TQD 106
HORIZONTAL WIRE SCAN
0.419" BELOW MEASURED VERTICAL CENTER
DATA OF 11/19/81
DOWNSTREAM POWER FLOW

RC WABBER
KC CAHILL