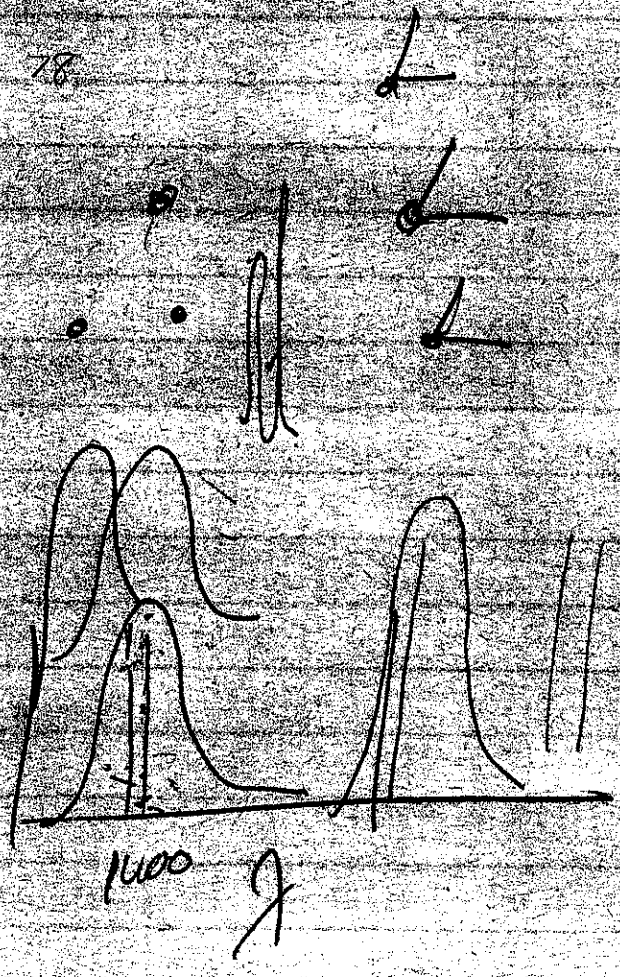
mwC

080 - #1 - 73, 73, 74
080 - #6 - 74, 73, 74
080 - #11 - 73, 73, 74
680 - #8 - 458, 462, 459
680 - #9 - 651, 655, 653
680 - #14 - 651, 652, 647
480 - #13 - 463, 469, 463
480 - #3 - 460, 461, 454
880 #5 - 837, 838, 840
680 #4 - 646, 649, 648
880 #10 - 829, 828, 833
280 #7 - 262, 263, 261
280 #12 - 266, 263, 253
880 #15 - 838, 829, 833
280 #2 - 256, 253, 251
280 #17 - 261, 265, 261
000 REF-1 0, 0, 0
000 REF-2 0, 0, 0
480 #18 - 453, 457, 453
080 #16 - 67, 68, 68
000 REF-3 0, 0, 0
680 #19 - 628, 632, 638
880 #20 - 824, 810, 818
000 REF-4 1, 0, 1

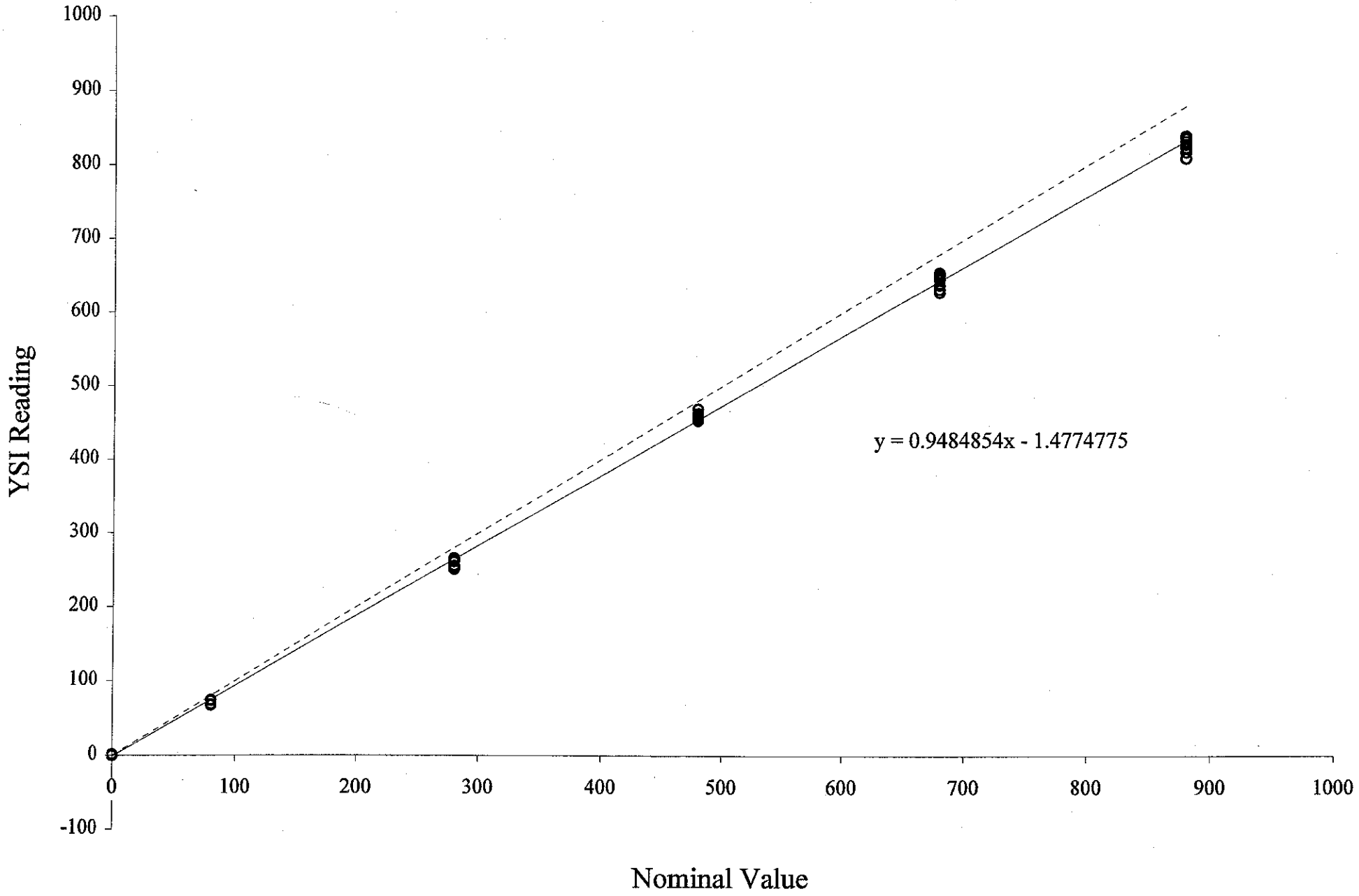
180 ± 4
500 ± 25
900 ± 45

80
280
480
680
880

568, 573, 563
384
186, 183, 183
385
78



Sample Concentrations



glucose	Urea	Intralipid

CONCENTRATIONS

C_{gs} = Glucose Stock Solution

C_{us} = Urea Stock Solution

C_{Is} = Intralipid Stock Solution

C_{gf} = Glucose final Solution

C_{uf} = Urea final Solution

C_{If} = Intralipid final Solution (4)

V_x = Volume of Stock Solution x (V_w is Volume of Water)

V_f is Volume of final solution

$$C_{gf} = \frac{C_{gs} V_g}{(V_g + V_u + V_I + V_w)} = \frac{C_{gs} V_g}{V_f}$$

$$C_{uf} = \frac{C_{us} V_u}{(V_g + V_u + V_I + V_w)} = \frac{C_{us} V_u}{V_f}$$ 3

$$C_{If} = \frac{C_{Is} V_I}{(V_g + V_u + V_I + V_w)} = \frac{C_{Is} V_I}{V_f}$$

$$V_g = \frac{C_{gf} V_f}{C_{gs}} \quad 2a$$

$$V_u = \frac{C_{uf} V_f}{C_{us}} \quad 2b$$

$$V_I = \frac{C_{If} V_f}{C_{Is}} \quad 2c$$

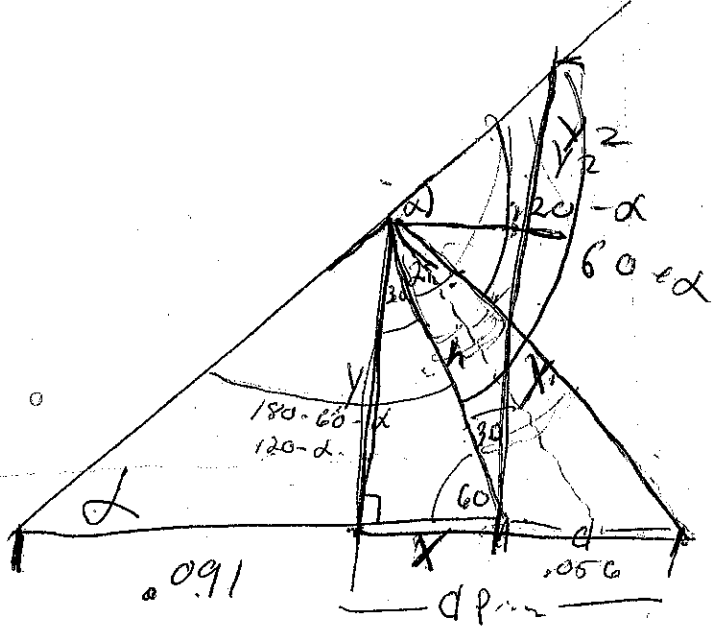
$$V_f \left(\frac{C_{gf}}{C_{gs}} + \frac{C_{uf}}{C_{us}} + \frac{C_{If}}{C_{Is}} \right) + V_w = V_f$$

$$\rightarrow V_f \left(1 - \left(\frac{C_{gf}}{C_{gs}} + \frac{C_{uf}}{C_{us}} + \frac{C_{If}}{C_{Is}} \right) \right) = V_w \quad (3)(4)$$

(1)

4

25
325
350
100



$y_1 = \frac{x}{\tan 30}$ $\quad y_2 = x \tan\alpha$

$y_1 + y_2 = .091 \tan\alpha$

$= x\left(\frac{1}{\tan 30} + \tan\alpha\right)$

$= x\left(\frac{1 + \tan\alpha \tan 30}{\tan 30}\right)$

$$\frac{.091 \tan\alpha \tan 30}{1 + \tan\alpha \tan 30} = x$$

$h = \frac{x}{\cos 60}$ $\quad y = h \sin 60$

$dprime = y \tan(30 + 2i)$

$2i = 180 - 2(120 - \alpha) = -60 + 2\alpha$

$dprime = y \tan(-30 + 2\alpha)$

$180 - (90 - L) - \alpha$

$d = dprime - x$

$180 - 90 - L - \alpha$

$90 + L - \alpha$

$d = y \tan(-30 + 2\alpha) - x$

$180 - 2(90 + L - \alpha)$

$d = h \sin 60 \tan(-2L + 2\alpha) - x$

$-2L + 2\alpha = 2i$

$= x \tan 60 \tan(-2L + 2\alpha) - x$

B12 -
$C_{MS} = 100$

Call Frank Tom.

$\varepsilon m/mk = 3.2577$ $\quad$ dens(bank)/dens(beam) = 7.5

$\varepsilon m/wa = 2.7651$ $\quad$ wa ~ 4.9

$wa/mk = 1.1781$ $\quad$ 1.5

Cuvette Experiment Description:

Purpose: verify the glucose predicting ability of the D-1000 for an in-vitro phantom whose optical properties mimic those of biological tissue.

Materials: Two 2.5mm light path cuvettes, glucose, urea, de-ionized water, whole milk powder, nitrogen tank with blow gun nozzle, isopropyl alcohol, methanol, acetone, 36 30ml glass jars with covers, 36 syringes with 16 gauge needles, lens tissue, D-1000 probe mountable cuvette holder.

Background: A paper by Beenen, Spanner and Niessner titled "Photoacoustic Depth-Resolved Analysis of Tissue Models" gives a recipe for a tissue phantom that mimics the optical scattering properties of skin. The recipe calls for 62g of whole milk powder to be dissolved in one liter of water. We can create such phantoms in-house and use them to study the glucose predicting ability of the D-1000. To do this, we need to vary the concentration of glucose in these phantoms over a range similar to that in skin tissue. The effect of changes in the magnitude of water absorbtion due to the displacement of water by glucose might overshadow the changes in magnitudes of glucose absorbtion. Thus, if we use PLS to create a calibration model using these phantoms, the B-vector could "lock" to water displacement in the phantoms instead of glucose. To avoid this situation, another water-soluble compound, urea, will be added to the phantom in concentrations varying independently from glucose.

Phantom Preparation: We will create phantoms with the following analyte concentrations:

Glucose Concentration: 0%, 0.1%, 0.3%, 0.5%, 0.7%, 0.9%
Urea Concentration: 0%, 2%, and 4%
Whole Milk Powder Concentration: 62g/L, 31g/L

There are 6 glucose concentrations, 3 urea concentrations and 2 scatter concentrations. So, 6 x 3 x 2 = 36 individual phantoms to be prepared. There are many different methods in which to prepare samples such as these. The preparation procedures may be different for each method, but the end results are identical. One such method for preparation is as follows:

Create three stock solutions; one of glucose and water, one of urea and water, and one of milk powder and water. Each stock solution should have an analyte concentration greater than the highest concentration of analyte required in the experiment. Let us define the following variables:

C_{gs} = Glucose Stock Concentration
C_{us} = Urea Stock Concentration
C_{ms} = Milk Powder Stock Concentration
V_f = Volume of Final Solution
C_{gf} = Glucose Final Concentration
C_{uf} = Urea Final Concentration
C_{mf} = Milk Powder Final Concentration
V_g = Volume of Glucose Solution

V_u =Volume of Urea Solution V_m = Volume of Milk Powder Solution
Where V_g, V_u and V_m are the volumes of the individual stock solutions added to the final solution.

We can write the concentration of the analytes in the final solutions in the following way:

$C_{gf} = (C_{gs} * V_g)/(V_g + V_u + V_m + V_w) = (C_{gs} * V_g)/V_f$
$C_{uf} = (C_{us} * V_g)/(V_g + V_u + V_m + V_w) = (C_{us} * V_g)/V_f$
$C_{mf} = (C_{ms} * V_g)/(V_g + V_u + V_m + V_w) = (C_{ms} * V_g)/V_f$

Where V_w is the volume of water added to the combination of the three stock solutions to create the final solution.

Thus, the volume required of stock solution x can be put in terms of the desired final concentration of analyte x, the stock solution concentration and the desired final volume as follows:

$V_x = (C_{xf} * V_f)/C_{xs}$ Where x may be g, u or m

The volume of water to be added to the combination of the three stock solutions in the final solution to achieve the desired concentrations of analytes is thus derived from the above equations and written as follows:

$V_w = V_f * (1 - (C_{gf}/C_{gs} + C_{uf}/C_{us} + C_{mf}/C_{ms}))$

Thus, with three stock solutions of known concentration, we can calculate the volume of each stock solution and the volume of water to be mixed together to create a predetermined volume of a final solution having predetermined concentrations of the three analytes.

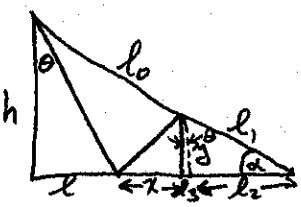
Each combination will be prepared, and 30 ml of it stored in a covered glass jar. To avoid correlation with confounding variables, spectra from each of the 36 samples should be measured five separate times. These 180 measurements should be taken such that the sample order is randomized.

Experimental Procedure: The cuvette holder will be fixed to the probe housing. The sample order must first be randomized and then grouped into 5 sets of 36 measurements. This ordering will be printed out and used at the lab table to keep track of measurements. The 36 sample jar lids will be labeled. Each individual sample will have its own 5ml syringe with a 16-gauge needle attached. This needle is to be used only with its designated sample to avoid cross contamination. The 180 measurements will be taken with the following procedure (two cuvettes can be used to make the process more efficient):

1. The cuvette must be cleaned.
    a. Fill the cuvette 1/3 full of DI water, shake and discard water.
        i. Repeat until water is clear
    a. Fill the cuvette 1/3 full of Isopropyl alcohol, shake and discard alcohol.
    b. Fill the cuvette 1/3 full of Methanol, shake and discard Methanol
    c. Before the inside of the cuvette begins to dry, blow nitrogen (15 psi) from a nozzle into the cuvette to evaporate the methanol without streaks.
    d. Clean the outside, front and back surface of the cuvette with Acetone.
2. Fill the cuvette with a sample using the syringe assigned to that sample.
3. Place the cuvette in the cuvette holder.
4. Using pccore, record 100 spectra.
5. Remove the cuvette from the holder after pccore finishes recording.
6. Empty the contents of the cuvette removed from the holder into the sample jar that it came from.

A calibration model will be created using the all of the spectra acquired from the above process. Follow up spectra will be recorded in a similar fashion as described above, but using only a few randomly selected samples. The calibration model will be used to predict the glucose concentration of the randomly selected follow up samples. The results will be reported in the form of an "error grid" plot.

Measurement Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Test # 1 Sample Number	5	4	10	11	6	9	22	33	7	30	18	26	4	2	25	2	32	30	7	34	14	35	36	2	22	28	4	10	35	3	34	19	3	18	23	29
Test # 2 Sample Number	18	17	17	11	9	13	21	16	6	26	15	13	6	17	33	18	33	19	23	15	22	27	32	30	12	20	31	16	36	8	17	23	27	24	35	31
Test # 3 Sample Number	27	12	7	16	36	5	11	33	13	28	10	8	31	24	24	24	26	23	6	19	29	25	11	22	22	35	4	14	24	34	10	1	3	7	15	20
Test # 4 Sample Number	1	28	14	12	5	31	30	20	3	16	23	6	25	33	9	16	29	34	15	32	8	14	12	32	25	5	19	25	21	21	1	7	18	19	21	36
Test # 5 Sample Number	34	21	1	2	3	20	8	13	12	32	30	11	2	28	29	26	35	14	15	27	8	5	36	17	13	9	10	1	9	4	26	29	31	20	27	28



~~$\frac{h}{x+l_3} = \tan(\theta+2i)$~~

$h = (l+x+l_3+l_2)\tan\alpha = [h\tan\theta + x + y\tan\theta + \tan\alpha]\tan\alpha = h\tan\theta\tan\alpha + x\tan\alpha + y\tan\theta\tan\alpha + y$

$h[1-\tan\theta\tan\alpha] = x\tan\alpha + y(\tan\theta\tan\alpha) + y = y[1+\tan\theta\tan\alpha] + x\tan\alpha$

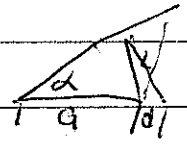
$h = \dfrac{y[1+\tan\theta\tan\alpha] + x\tan\alpha}{1-\tan\theta\tan\alpha} = \dfrac{.091[\tan\theta+\tan\alpha][1+\tan\theta\tan\alpha] + x\tan\alpha}{1-\tan\theta\tan\alpha}$

$l_2+l_3 = 0.091 = \dfrac{y}{\tan\alpha} + y\tan\theta = y\left[\dfrac{1}{\tan\alpha}+\tan\theta\right] = y\left[\dfrac{\tan\theta\tan\alpha+1}{\tan\alpha}\right] \Rightarrow y = \dfrac{.091\tan\alpha}{1+\tan\theta\tan\alpha}$

$\therefore\ l_0+l_1 = \dfrac{.091[\tan\theta+\tan\alpha][1+\tan\theta\tan\alpha] + x\tan\alpha}{\sin\alpha[1-\tan\theta\tan\alpha]}$

$l_0+l_1 = \dfrac{0.091\tan\alpha + x\tan\alpha}{\sin\alpha[1-\tan\theta\tan\alpha]} = \dfrac{(.091+x)\tan\alpha}{\sin\alpha[1-\tan\theta\tan\alpha]} = \dfrac{0.091+x}{\cos\alpha[1-\tan\theta\tan\alpha]}$

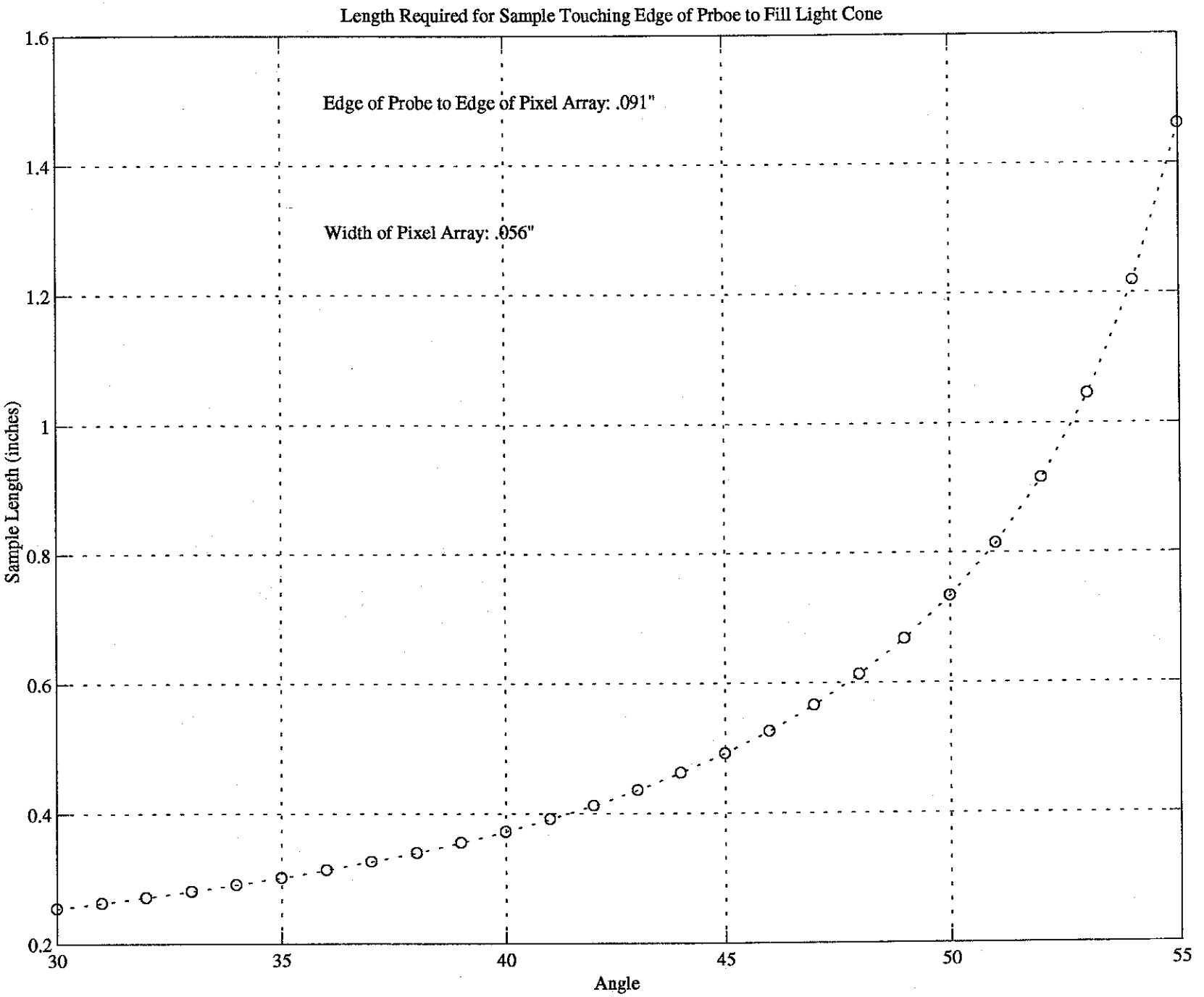
x	θ	α	l_0+l_1	
.056	30	33	~~0.558~~	0.280
		35	~~0.593~~	0.301
		40	~~0.719~~	0.372
		45	~~0.945~~	0.492

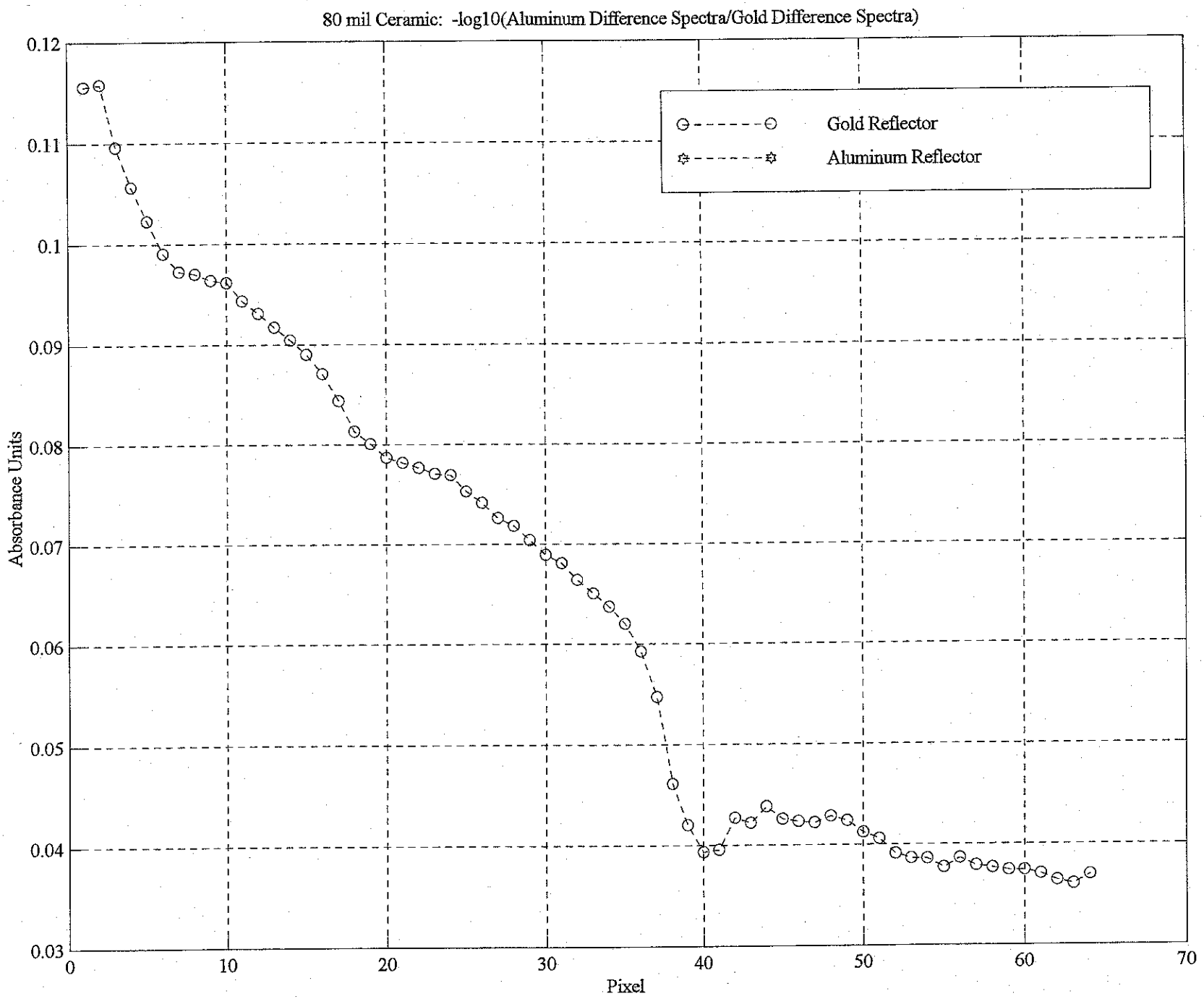


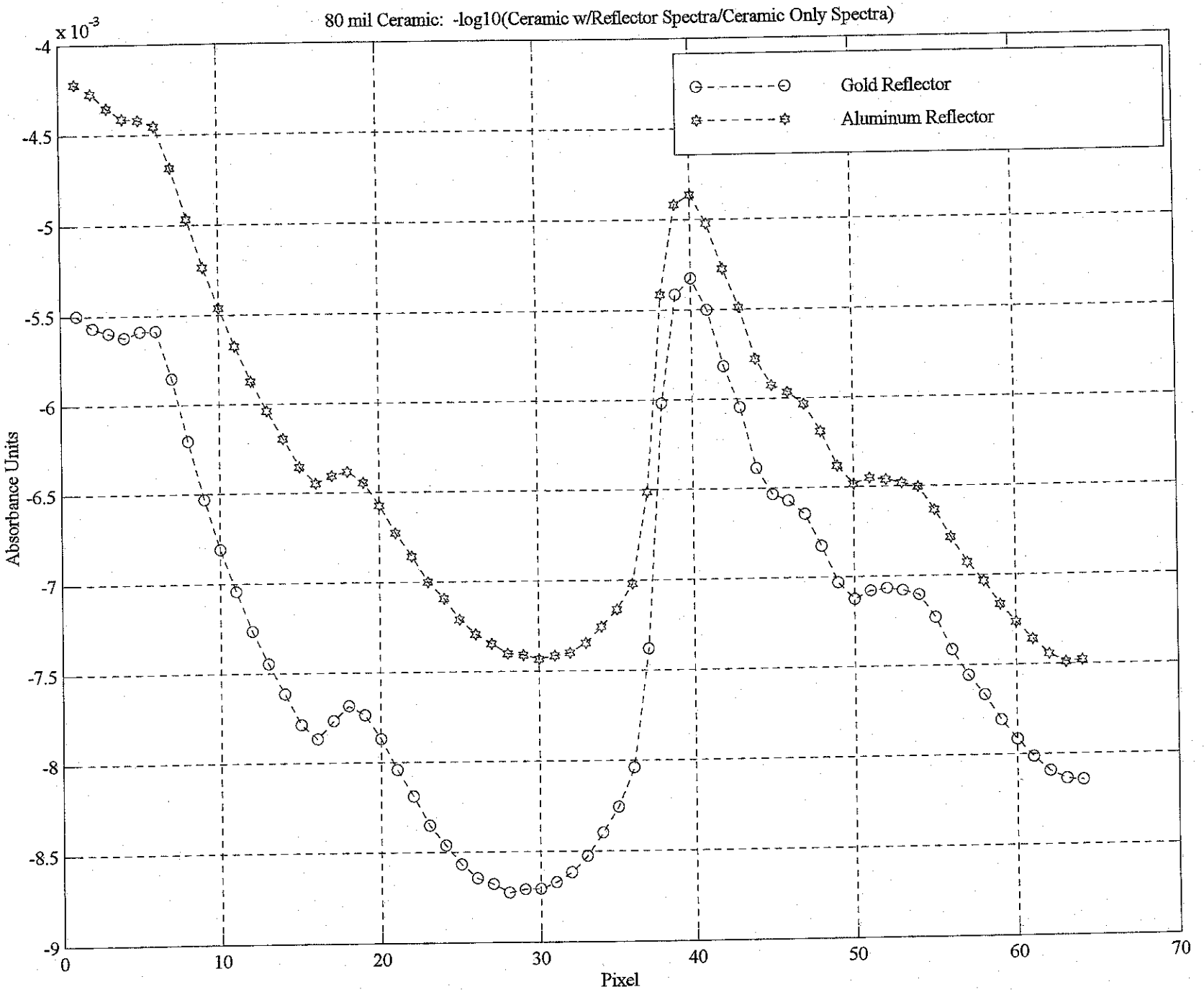
$d = x\left[\tan(90-L)\ \tan(-2L+2\alpha) - 1\right]$

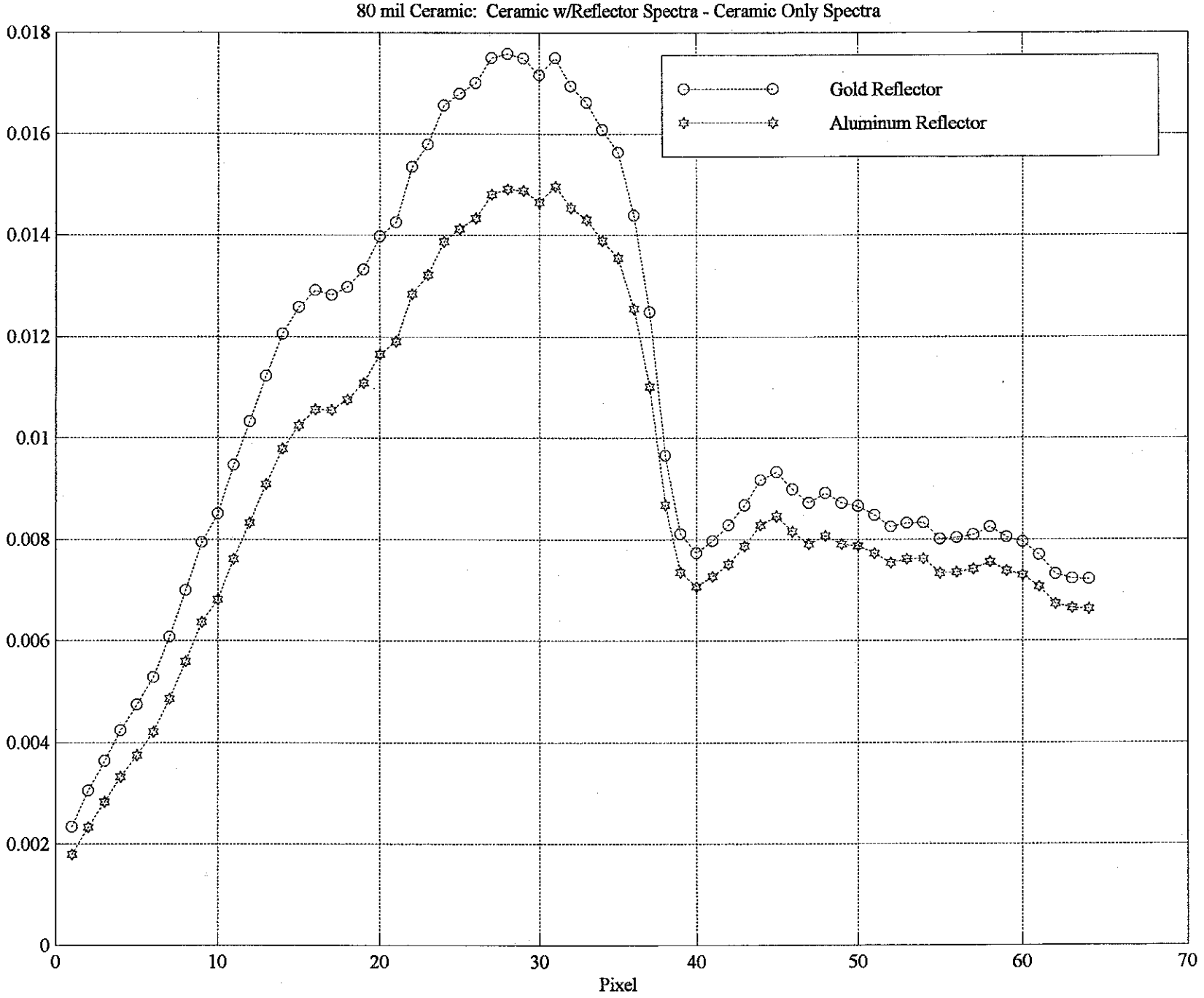
$x = \dfrac{a\tan\alpha\tan L}{1+\tan a\tan L}$

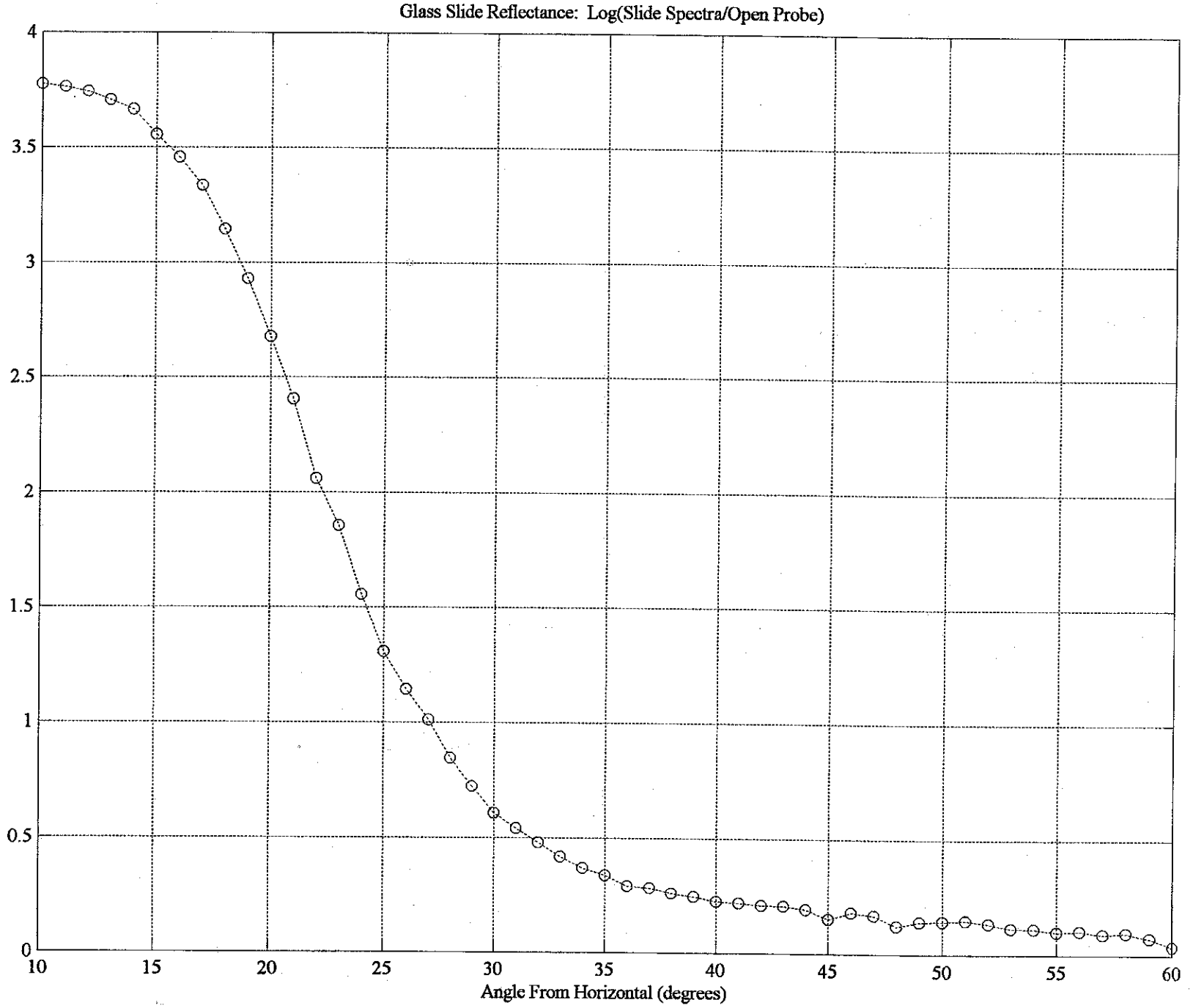
$d = a\tan\alpha\tan L\left(\tan(90-L)\tan(-2L+2\alpha) - 1\right) / (1+\tan\alpha\tan L)$

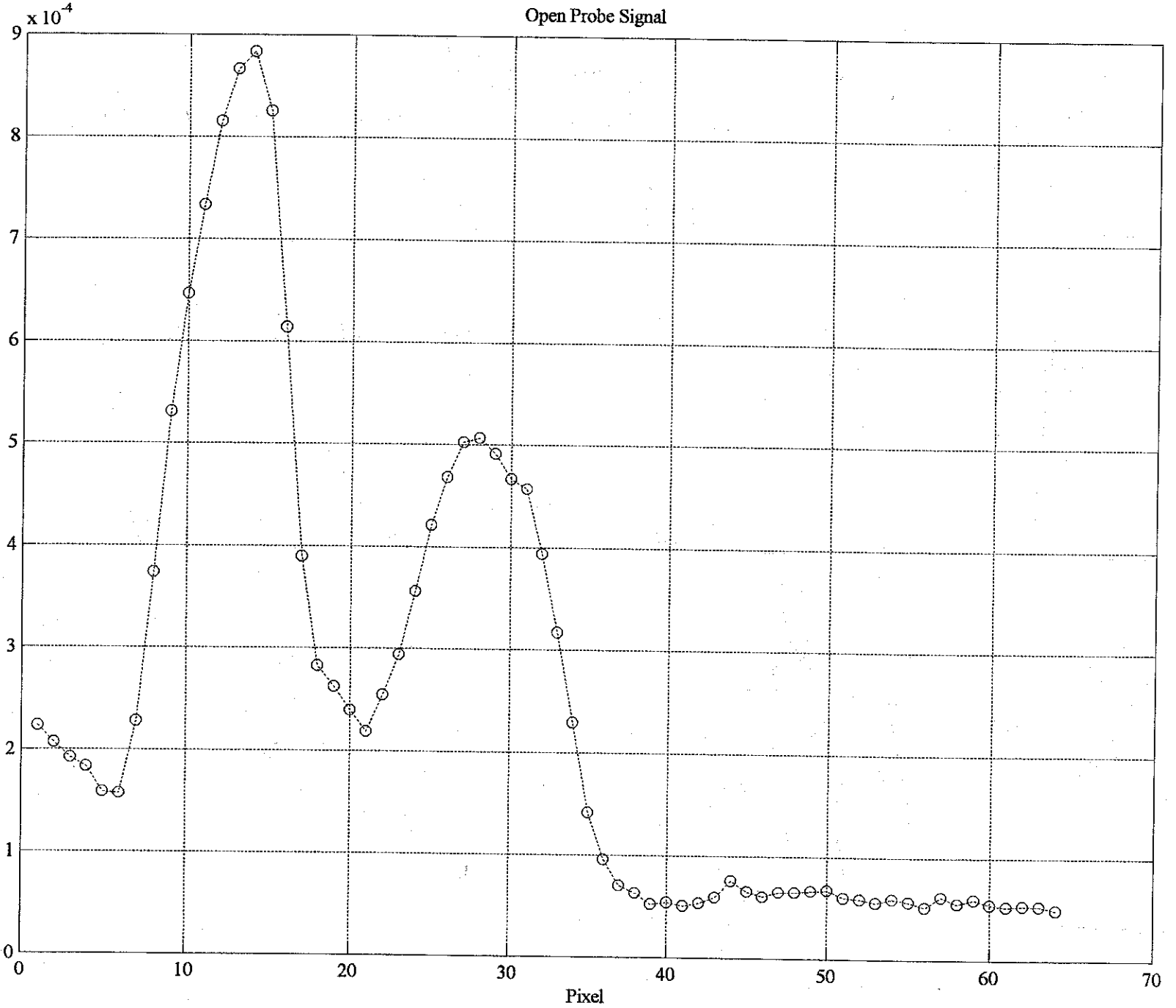

Length Required for Sample Touching Edge of Prboe to Fill Light Cone
Edge of Probe to Edge of Pixel Array: .091"
Width of Pixel Array: .056"
Sample Length (inches)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
30
35
40
45
50
55
Angle

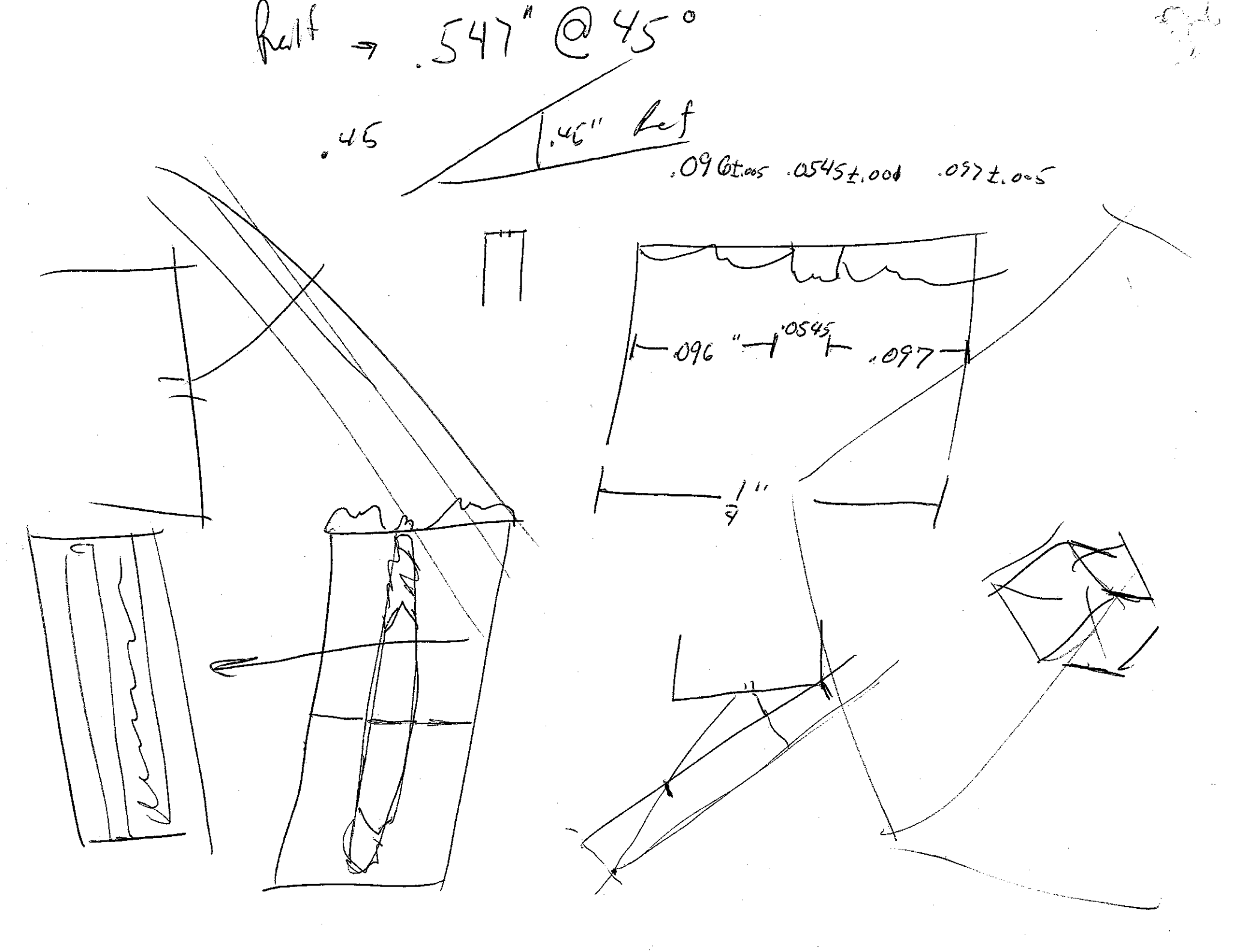

80 mil Ceramic: -log10(Aluminum Difference Spectra/Gold Difference Spectra)
Gold Reflector
Aluminum Reflector
Absorbance Units
Pixel
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0
10
20
30
40
50
60
70

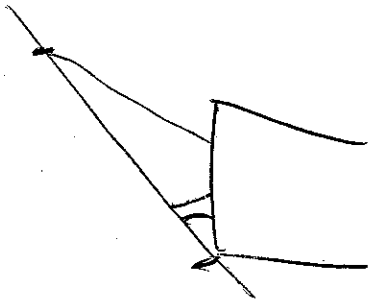

80 mil Ceramic: -log10(Ceramic w/Reflector Spectra/Ceramic Only Spectra)
x 10^-3
-4
-4.5
-5
-5.5
-6
-6.5
-7
-7.5
-8
-8.5
-9
Absorbance Units
0
10
20
30
40
50
60
70
Pixel
Gold Reflector
Aluminum Reflector

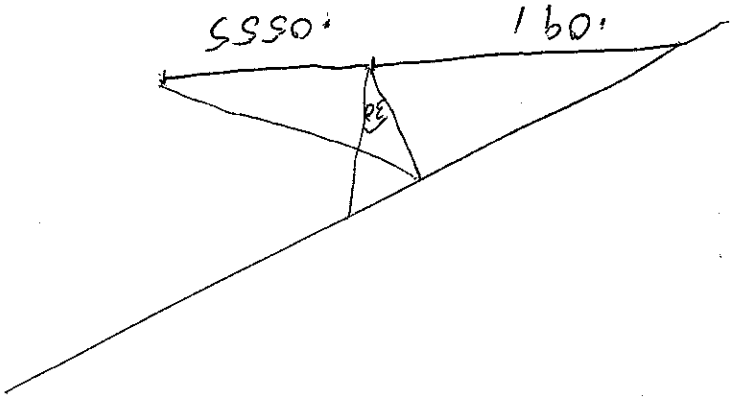

80 mil Ceramic: Ceramic w/Reflector Spectra - Ceramic Only Spectra
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
10
20
30
40
50
60
70
Pixel
Gold Reflector
Aluminum Reflector


Glass Slide Reflectance: Log(Slide Spectra/Open Probe)
4
3.5
3
2.5
2
1.5
1
0.5
0
10
15
20
25
30
35
40
45
50
55
60
Angle From Horizontal (degrees)


Open Probe Signal
x 10^-4
9
8
7
6
5
4
3
2
1
0
0
10
20
30
40
50
60
70
Pixel


Ref → .547" @ 45°
.45
.46" Ref
.096±.005
.0545±.001
.097±.005
.096"
.0545
.097
1"




55550'
180'
38

Cuvette-experiment :

GOAL :- The goal of this experiment is to verify the glucose-predicting ability of D1000 in an *in-vitro* phantom whose optical properties mimic that of biological tissue.

MATERIALS :- Three 2mm quartz cuvettes, glucose, DI water, polystyrene latex spheres (1.05 μm dia), urea.

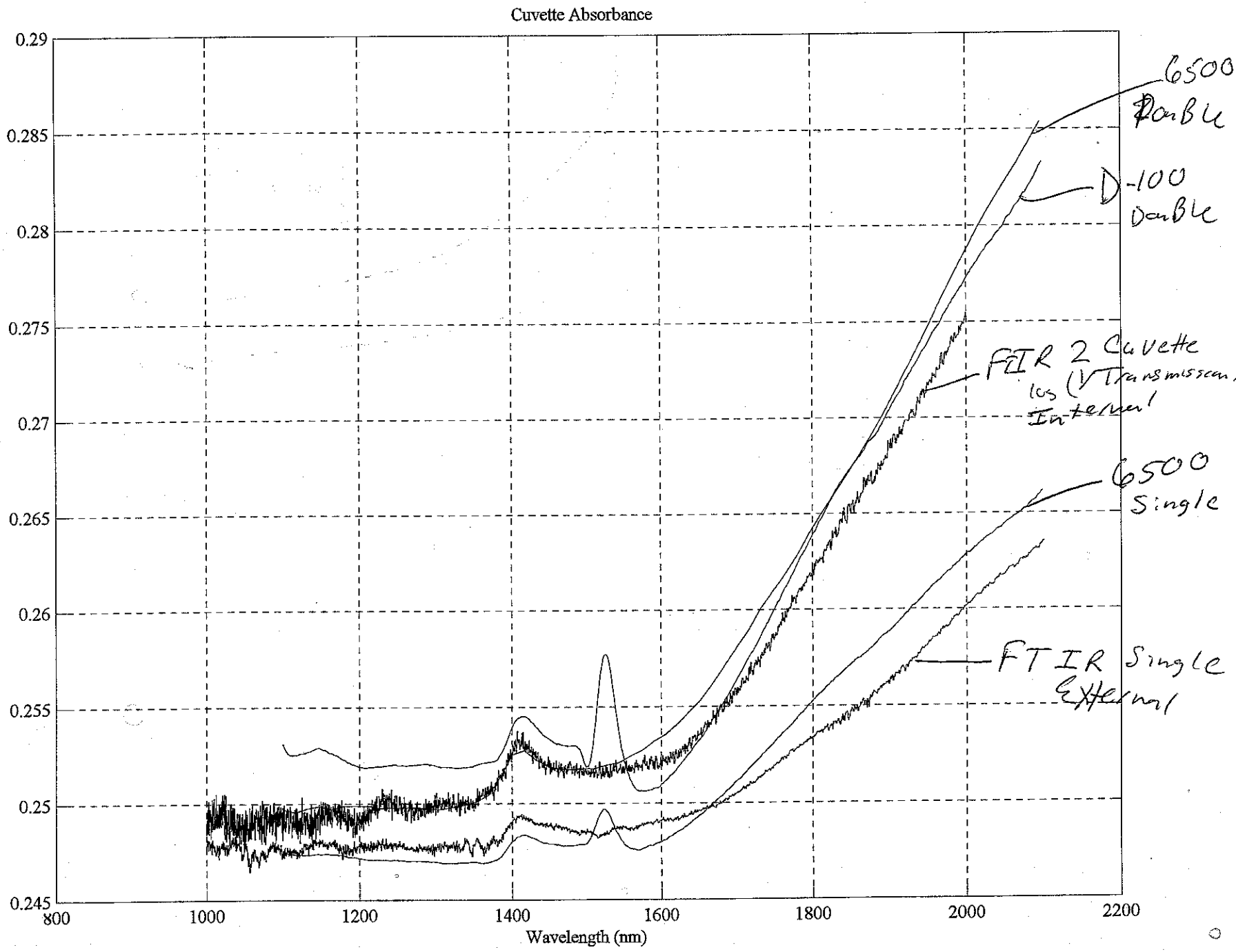
BACKGROUND :- A simple tissue phantom whose scattering and absorption properties mimic that of biological tissue can be made in-house. Glucose being the analyte of interest, its concentration would be varied from 0 mg/dL to 800 mg/dL in the suspension. Biological tissues have approximately 70% to 90% water, and hence, water is chosen as the base solvent for the suspension. Turbidity on the suspension can be achieved by adding polystyrene latex spheres. Its volume fraction can be adjusted to achieve a particular value of scattering coefficient of the suspension. The effect of changes in the magnitude of water absorption due to displacement of water by glucose might overshadow the changes in magnitudes of glucose absorption. Thus if we use PLS to create a calibration model, the B-vector could "lock" to water changes instead of glucose changes. To avoid this situation another water-soluble compound, urea, is added to the suspension whose volume fraction can be varied independently. In order to mimic the actual application , the ambient conditions like temperature and humidity will not be controlled.

PHANTOM PREPARATION :- The reduced scattering coefficient of the suspension would be kept at 1.0 and 1.5 mm^{-1} (at 1100 nm) by adjusting the volume fraction of intralipid. For each of these two scattering coefficients, fix the glucose concentration at one value from 0.0 to 0.8% volumetrically (in the steps on 0.1%). For each glucose concentration, vary the urea fraction from 0% to 4% (in the steps of 1%). The volume fraction of the fourth compound, water, would be 100 - [glucose% + urea% + intralipid%]. Thus, we can have 2 x 5 x 9 = 90 phantoms.

EXPERIMENTAL PROCEDURE :- After the machine has stabilized, take a reference spectrum with an empty cuvette. Then fill the cuvette with one of the 90 different combinations of the suspension, and take another spectrum. Pull out the cuvette and repeat the above with another cuvette. In the mean time, clean the first cuvette. The following points should be taken care of while taking the spectra (on calibration as well as prediction day):

1. Randomize the selection of these 90 samples.
2. Use one particular concentration sample in all the three cuvettes, at the beginning, middle and the end of the day to account for the cuvette variations.

Once the spectra has been collected for the entire calibration day, use PLS to create the calibration model. This model would later be used to predict the glucose concentration of the samples on the following days for a period of 4 weeks. The results would be shown in error grids and remember, all outlier criteria should be turned off.


Cuvette Absorbance
0.29
0.285
0.28
0.275
0.27
0.265
0.26
0.255
0.25
0.245
800
1000
1200
1400
1600
1800
2000
2200
Wavelength (nm)
6500 Double
D-100 Double
FTIR 2 Cuvette
6500 Single
FTIR Single External

Duke Scientific Corporation

2463 Faber Place
P.O. Box 50005
Palo Alto, CA 94303

Toll Free: 800-334-3883
or: 415-424-1177

FAX: 415-424-1158

email: echae@dukesci.com

DATE: June 16, 1997

FAX #: 412 349 8610

COMPANY: Biocontrol Technologies

ATTN: Jeremy Grata

FROM: Liz Chae

RE: Settling velocity of particles

Total Pages: 1

Hi Jeremy,

Here is the formula for the settling velocity of particles:

$$V = \frac{(\rho_p - \rho_f) d^2 g}{18\eta}$$

where:

$\rho_p = 1.05$ g/cc

ρ_f = density of fluid

d = diameter of particle, cm

g = gravity $\approx 981 \text{cm/s}^2$

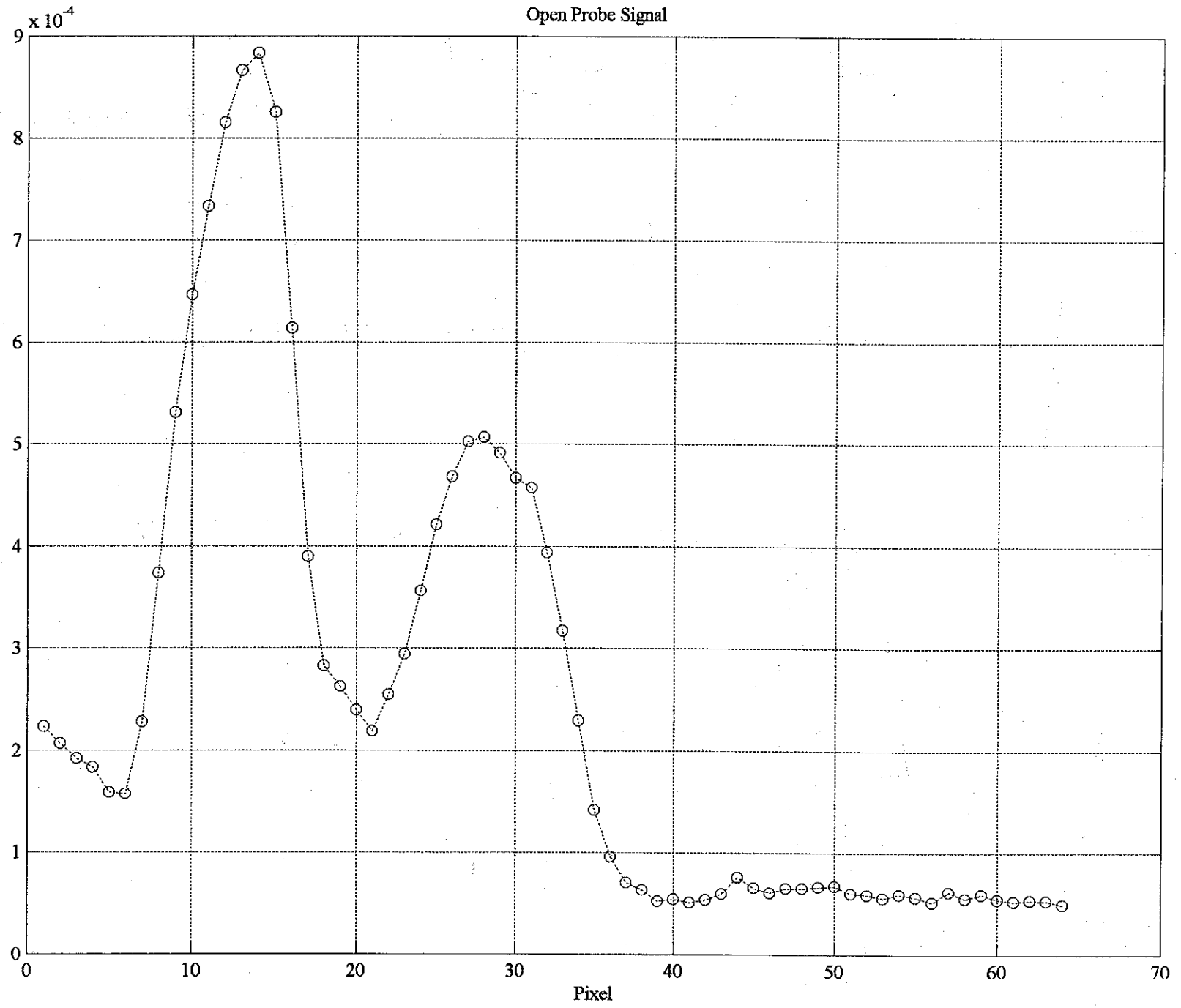
η = fluid viscosity $\approx 0.01 \frac{\text{dyn} \cdot \text{s}}{\text{cm}^2}$

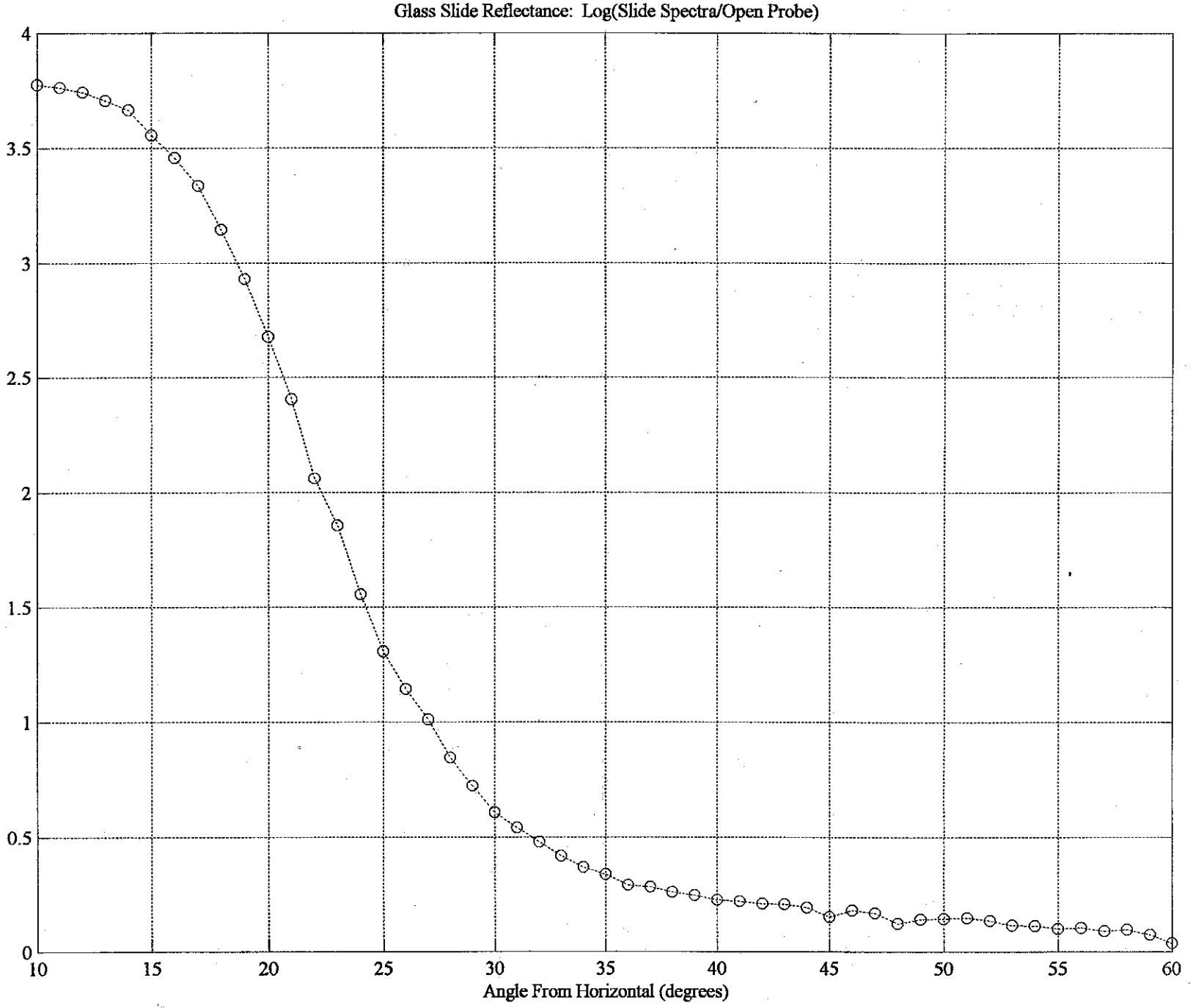
V = velocity $= \frac{\text{cm}}{\text{s}}$

Contact me if you have further questions or comments.

Sincerely,

Liz Chae


Open Probe Signal
x 10^-4
9
8
7
6
5
4
3
2
1
0
0
10
20
30
40
50
60
70
Pixel


Glass Slide Reflectance: Log(Slide Spectra/Open Probe)
4
3.5
3
2.5
2
1.5
1
0.5
0
10
15
20
25
30
35
40
45
50
55
60
Angle From Horizontal (degrees)