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DUMAND—Deep Underwater Muon and Neutrino Detection

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DUMAND Internal Note 80-1

To: DUMANDers

From: D. J. McGibney

Subject: Results of SEA URCHIN Spine Efficiency Tests

Introduction

Preliminary tests designed to measure the response capability of the SEA URCHIN spine to simulated Cerenkov radiation have been completed using an 8-ft. long 1-in. diameter spine filled with a wavelength shifting (WLS) fluor dissolved in toluene. A spine efficiency has been determined by comparing the direct measured response of a photomultiplier tube (PMT) to simulated Cerenkov light illumination with the measured light output at the end of the spine exposed to the same illumination.

Discussion

Figure 1 shows a schematic of the experimental apparatus used to determine spine efficiency. In order to sample the light output at one end of the spine the sample spine was illuminated with an ultraviolet pen light diffuse source (S) covered by a theatrical gel "brilliant blue" filter to simulate as close as possible the Cerenkov spectrum in the ocean. This source is located approximately 16 ft. from the spine. In these tests both a 56 AVP-S11A cathode and a 150 CVP-S20 cathode PMT were optically coupled to one end of the spine to measure the fluorescent emission output of the illuminated spine. The integrated spectral signal (containing all emission wavelengths) output was measured in multivolts (mV) by a lock-in amplifier tuned to 120 Hz (twice the line frequency of the 60 Hz u.v. pen light modulation). The output signal could also be monitored on the oscilloscope. The fluorescent WLS used was HOSTASOL Yellow 8G with a concentration of 50 mg/liter dissolved in toluene. This is one of two fluors considered suitable for use with the SEA URCHIN module. Details on the 8G emission spectral response relative to other candidate fluors are discussed in detail in Ref. (1). A concentration of 50 mg/ℓ was found to give the greatest fluorescent yield for the WLS dye. Data were obtained by shielding all of the spine from the illumination except for a length L (L = 25 cm) along the spine and varying the position of the exposed region with respect to the detector. This position is given as distance D from the PMT (see Fig. 1). Readings in mV from the lock-in amplifier were recorded as a function of the distance D. Readings were taken for two different plate voltage settings to test for consistency of results. Two different PMTs were used to observe how the spine efficiency may vary with PMT photocathode type.

The fluorescent emission data measured above was compared with the direct response of the PMT to the light illumination from the source S. Data on direct PMT response was taken by exposing exactly 4 cm^2 of the PMT face to the illumination at various positions along the spine as shown in Fig. 1. Readings were not observed to change more than 10% at these positions. An average of these values were taken as a baseline value. The spine efficiency was thusly defined for data taken at any specific distance D from the PMT as equal to:

$$\frac{\text{Area of PMT exposed}}{\text{Area of spine exposed}} \times \frac{\text{emission signal (mV)}}{\text{direct average PMT signal}} .$$

As stated the area of the PMT exposed was 4 cm^2 and the area of spine exposed at any position D from the detector was consistently (L = 25 cm x spine diameter = 2.5 cm) equal to 62.5 cm^2. Thus the efficiency:

$$\varepsilon = 4/62.5 \times \frac{\text{emission signal}}{\text{direct PMT signal}} .$$

Figure 2 shows a plot of the measured spine emission signal as a function of the distance of the exposed region from the PMT detector. The PMT used in this case was the AMPEREX 150 CVP with the S-20 photocathode. The two curves are plotted for data obtained first with a plate voltage of 1.05 KV and then with 0.90 KV. In computing efficiency (ε) the direct PMT signal measured (4 cm^2 area) was 47 mV for a voltage of 1.05 KV and 12.6 mV for a PMT voltage of 0.90. For 1.05 KV the computed spine efficiencies (shown in parenthesis) varied from 5.4% nearest the detector to 1.5% farthest from the detector. For 0.90 KV this variation goes from 5.6% to 1.7%. The attenuation length as observed for both these sets of data are approximately 1.3 M. This value should not be taken too literally since as noted in Ref. (1) the actual attenuation length is a combination of many attenuation lengths ~~as. a combination of many attenuation lengths~~ (corresponding to different frequency components) which are a function of the length of the spine. This is further complicated by the fact that illumination along the spine in this experimental set-up is not uniform.

Figure 3 gives a similar set of data as Fig. 2 for a 56 AVP-S11A photocathode PMT. Spine efficiencies vary from 5.7% to 1.2% for a PMT voltage of 1.05 KV and from 6.0% to 1.9% for a voltage of 0.90 KV. The observed attenuation length is again shown to be about 1.3 M.

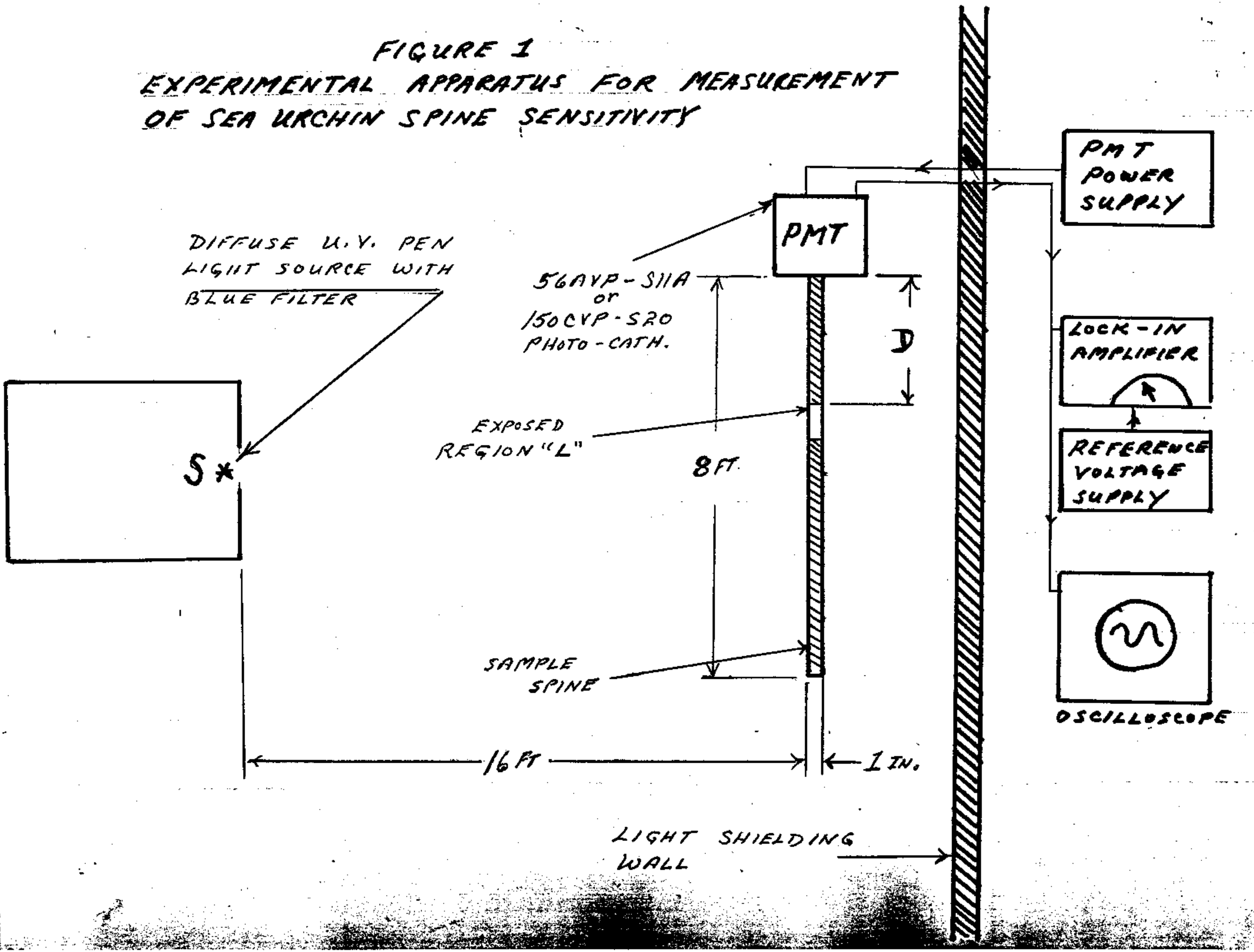
Results

The results of Figs. 2 and 3 show an average spine efficiency of 3.3% for the S-20 photocathode and a slightly better 3.7% efficiency for the S11A cathode. This is not surprising since in this spectral response region of of 510 nm, the cathode efficiency varies rapidly with the S11A having a better relative response to the HOSTASOL 8G emission spectrum as shown in Ref. (1), Table 1. No statistically significant difference is noted using different PMT voltages.

REFERENCES

1. "Design of the SEA URCHIN Module, II, Spine Design," by D. McGibney and A. Roberts, Hawaii DUMAND Center; DUMAND Note 80-14, 1980; to be published in Proc. of 1980 DUMAND Summer Symposium-Workshop.

FIGURE 1
EXPERIMENTAL APPARATUS FOR MEASUREMENT OF SEA URCHIN SPINE SENSITIVITY



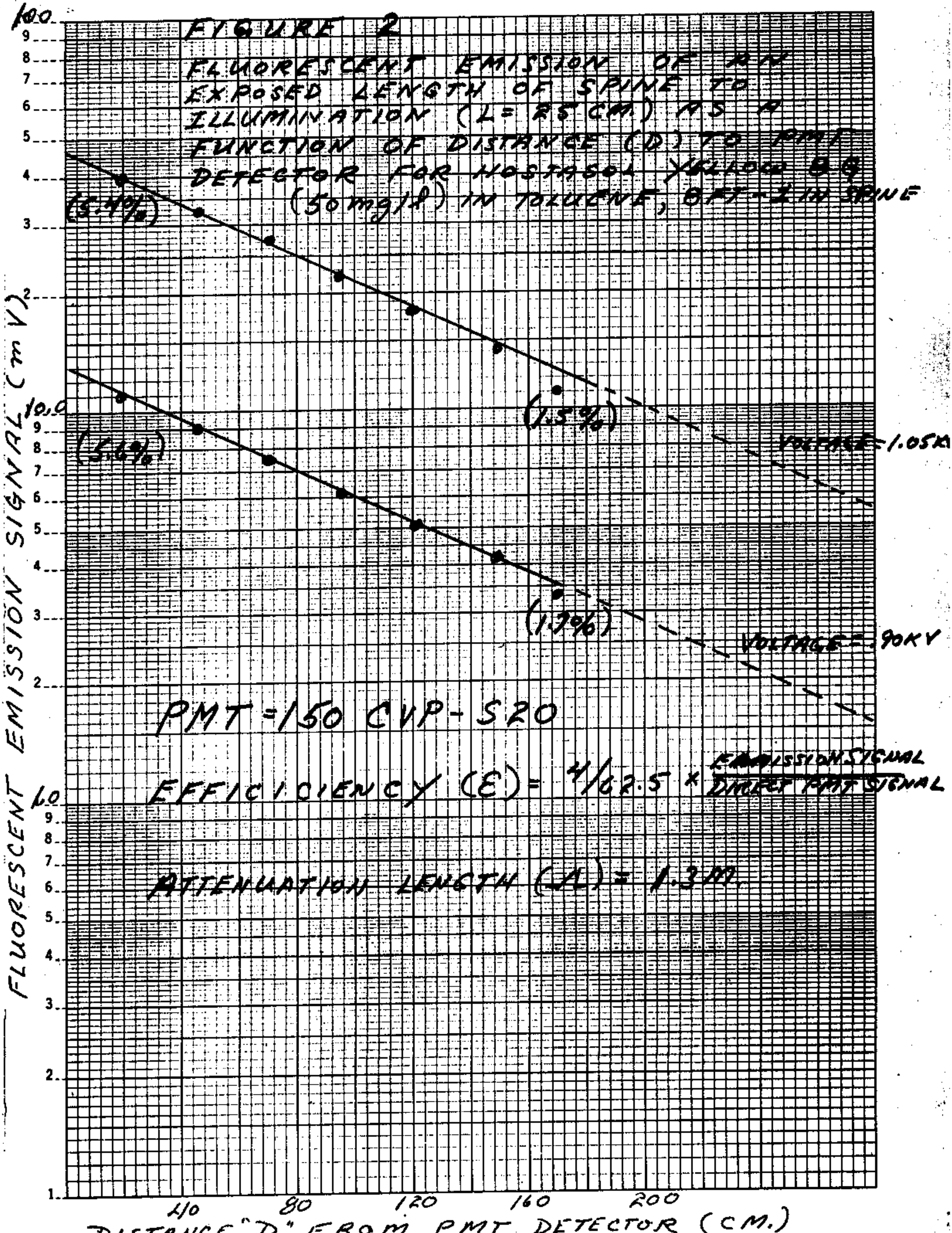


FIGURE 2
FLUORESCENT EMISSION OF AN EXPOSED LENGTH OF SPINE TO ILLUMINATION (L= 25 CM) AS A FUNCTION OF DISTANCE (D) TO PMT DETECTOR FOR HOSTASOL YELLOW 8G (50mg/l) IN TOLUENE, BFT-2 IN SPINE
100
10.0
1.0
(5.4%)
(1.5%)
(5.6%)
(1.7%)
VOLTAGE=1.05KV
VOLTAGE=.90KV
PMT=150 CVP-S20
EFFICIENCY (E)= 4/62.5 × EMISSION SIGNAL / DIRECT PMT SIGNAL
ATTENUATION LENGTH (λ)= 1.3M.
FLUORESCENT EMISSION SIGNAL (mV)
40
80
120
160
200
DISTANCE "D" FROM PMT DETECTOR (CM.)

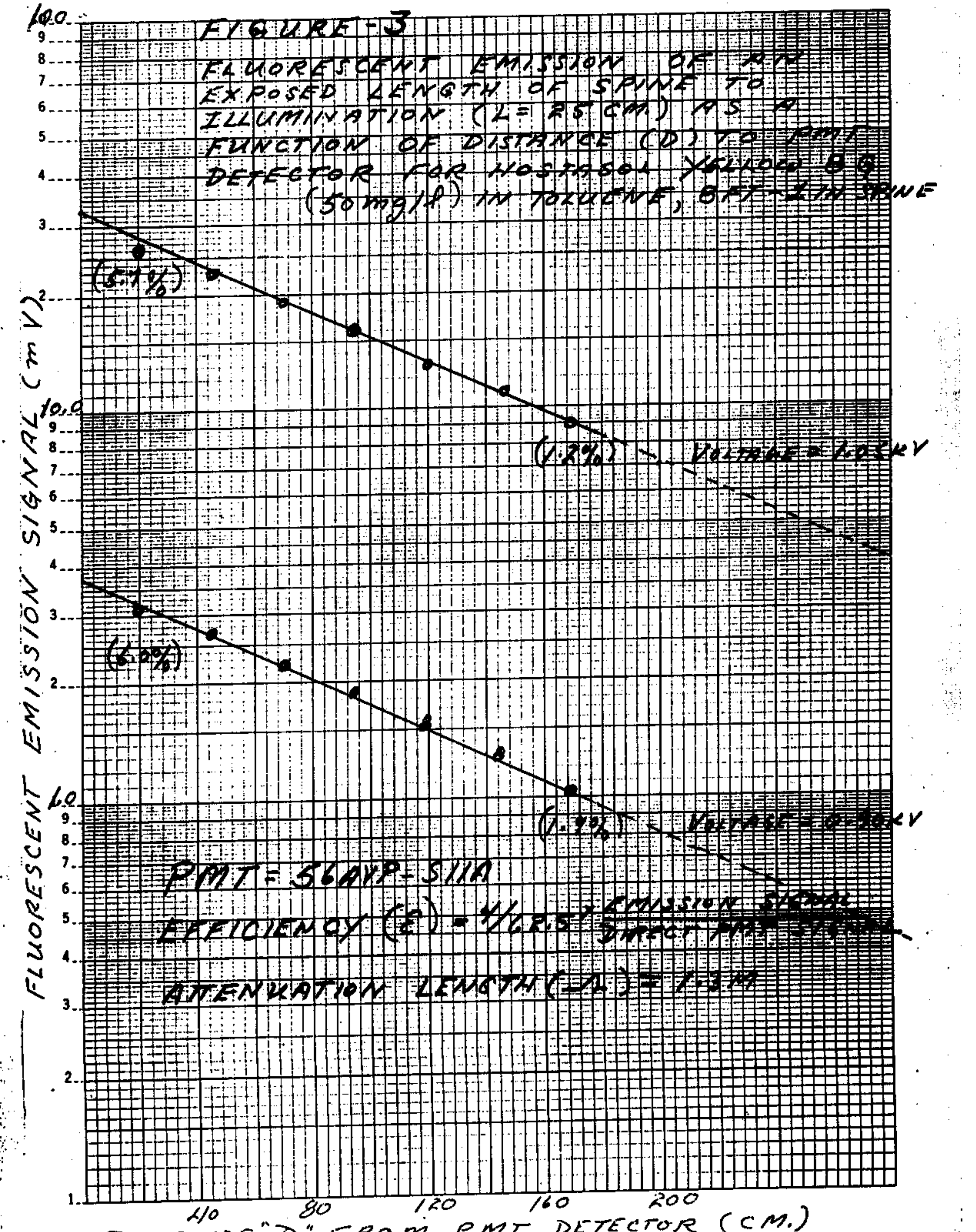


FIGURE-3
FLUORESCENT EMISSION OF AN EXPOSED LENGTH OF SPINE TO ILLUMINATION (L= 25 CM) AS A FUNCTION OF DISTANCE (D) TO PMT DETECTOR FOR HOSTASOL YELLOW 8G (50 mg/l) IN TOLUENE
FLUORESCENT EMISSION SIGNAL (mV)
100
10.0
1.0
(5.1%)
(4.2%)
(6.0%)
(1.9%)
PMT = 56AVP-SIIA
EMISSION SIGNAL
ATTENUATION LENGTH
40
80
120
160
200
"D" FROM PMT DETECTOR (CM.)