PMT REQUIREMENTS FOR DUMAND: A PRELIMINARY SUMMARY

by
A. ROBERTS

Hawaii DUMAND Center

ABSTRACT

Design work on the Sea Urchin module has made clear many of the requirements for a PMT suitable for DUMAND. The signal processing workshop held in February 1980 has also clarified some of the requirements. Consequently we can now enumerate with confidence what the requirements for the PMT should be.

1.0 INTRODUCTION

We enumerate the headings under which the tube specifications will fall.

1.1 Tube envelope, shape.

The photocathode must be deposited inside a hemispherical shell, of diameter about 8" (20 cm).The mode of operation of the Sea Urchin detector requires that it cover the full hemisphere, as nearly as possible.

The remainder of the tube envelope is not critical, except that it must allow support of the PMT against an external seal, whose function is to prevent leakage of the optical coupling liquid around the tube.

1.2 Cathode Specifications.

The response of the photocathode is dictated by the spectrum of the fluor used. That, in turn, depends on the nature of the fluor and on the incident Cerenkov light. The latter, after traversing seawater, is narrowed to about 400 - 520 nm, peaking near 450 nm. As described elsewhere, ( ) the best fluors available for absorption in that region have responses peaking between 510 and 540 nm. The photocathode must accordingly be selected to give optimum response in the range 500 -600 nm. We would hope for an average detection efficiency for the fluorescent light of 10%.

In addition to the Cerenkov signals, there is also a Cerenkov background, of identical spectral characteristics, due to Cerenkov light produced in the ocean by K40. This is highly diffuse, and consists almost entirely of single uncorrelated photons. Therefore there will be a large background of signle-photoelectron pulses. The ability to detect signals over this background requires that the single-electron background be suppressed.

To achieve this, it is necessary to be able to distinguish single-electron pulses from larger ones; otherwise a threshold that discriminates against single-electron counts will lose too many larger pulses. For this reason a high-gain first dynode is a necessity. The gain must be sufficient so that with a background of 100000 single-electron pulses/sec, the number of spurious 2-electron pulses should not exceed at most a few hundred, and should be negligible for 3-electron pulses.

1.3 Large-Pulse Background.

Photomultipliers generally have a dark current which includes a single-electron component due to thermionic emission, and a background of larger pulses, due to secondary electron emission from the cathode excited by positive ions. The latter are formed in the volume between the photocathode and the first dynode, by accelerated photoelctrons that collide with gas atoms. Unless the photocathode is equipped with a suppressor grid in front of it, run at a potential more positive than the first dynode, the positive ions are accelerated to the photocathode and produce large pulses.

This background is of great importance to DUMAND, where event selection is by pulse height, and where we search for a few pulses of 3 or more electrons in an enormous background of single-electron pulses. We may perhaps be able to take advantage of the fact that the large background pulses are delayed with respect to the primary electrons, and thus reduce the background. If the suppressor grid is feasible without excessive reduction of cathode efficiency, it should effect a large reduction in this type of background.

If, on the other hand, it is not, the aim should be first, to reduce large background pulses to a minimum; and second, to insure that most of them are delayed with respect to single-electron primary pulses; and third, if possible, to minimize that delay time. The last of these makes it easier to gate them out.