

9.11 Applications to Laser Measurement

Recently, lasers are being applied to a wide range of measurement and processing applications owing to their superior advantages such as spatial or temporal coherency and high optical power.

Applications utilizing lasers can be classified as follows:

1) Measurement

Rangefinder, laser radar, holography, laser chemistry, medical measurement

2) Data processing

Optical communications, optical data processing

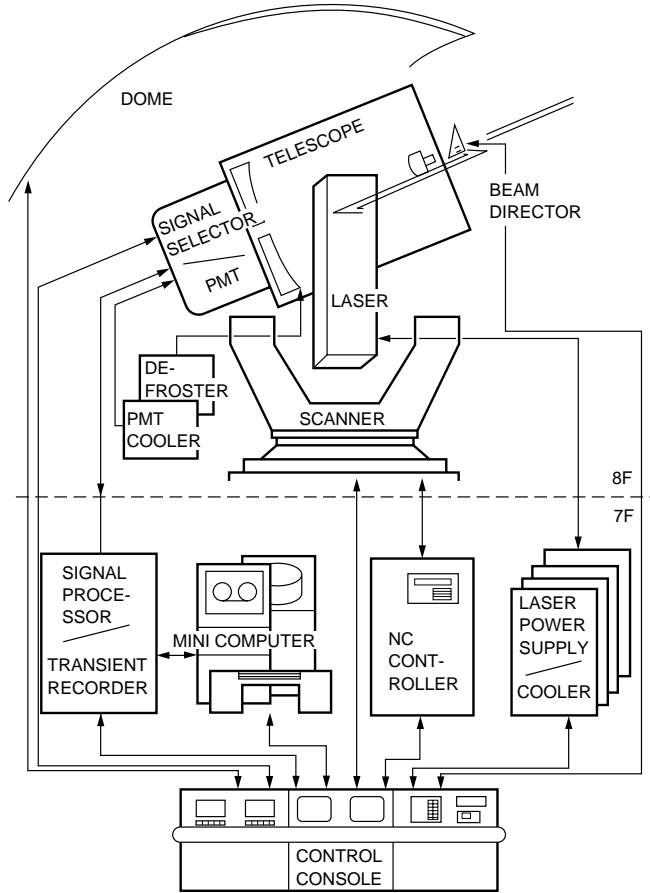
3) Energy sources

Laser processing, laser fusion, laser scalpel

This section explains typical applications of photomultiplier tubes used in laser measurements and major characteristics required.

9.11.1 Overview

Laser measurement applications using photomultiplier tubes include laser radars for rangefinding and atmospheric observation and laser spectroscopy such as fluorescence lifetime measurement. For signal processing in these measurements, the photon counting mode is widely used rather than analog mode, in order to improve the signal-to-noise ratio and enhance the detection limit. Furthermore, time correlated photon counting (TCPC) technique is employed in picosecond measurements such as fluorescence lifetime determination. Figure 9-50 illustrates the block diagram of a laser radar used for atmospheric observation,³³⁾ installed at the National Environmental Pollution Laboratory, Tsukuba, Japan.



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Figure 9-50: Schematic construction of a laser radar for atmospheric observation

9.11.2 Major characteristics required of photomultiplier tubes

The following photomultiplier tube characteristics are essential in this field.

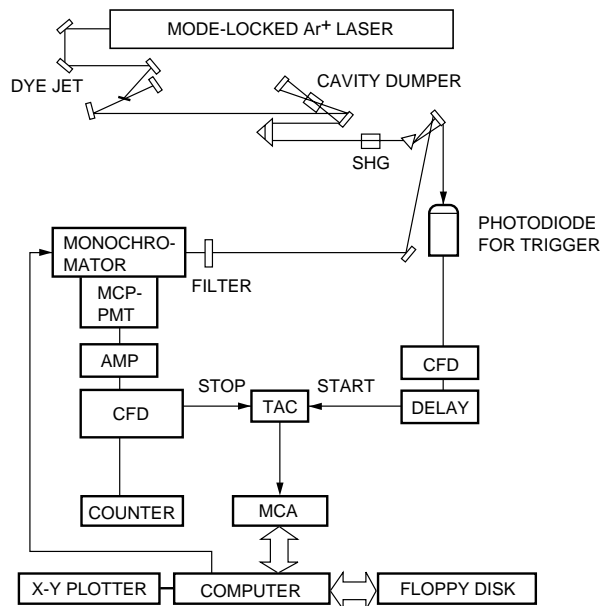
- a) Fast time response
- b) Low noise
- c) High gain

Of these, time response is the most important factor. With the development of laser technology, photomultiplier tubes with faster time response are in greater demand. In particular, electron transit time spread (TTS) is important for picosecond resolution in measuring fluorescence lifetime.

The TTS (transit time spread) is greatly affected by CTTD (cathode transit time difference) and wavelength effects (Refer to Section 3.3.1, "Time characteristics".) These effects sometimes cause significant problems in normal photomultiplier tubes using discrete dynodes, but create very few problems with an MCP-PMT. Normally, noise should be as low as possible to achieve a high signal-to-noise ratio and especially, the dark count must be small.

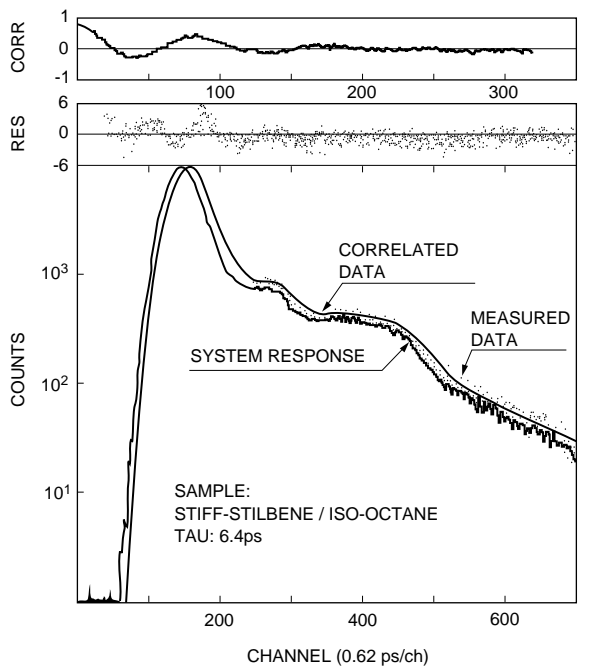
The gain should be high enough to obtain a good pulse height distribution in single photon events, in other words, a distinct valley should exist in the single-photoelectron pulse height distribution. Typically, gain of 5×10^6 is necessary.

Figures 9-51³⁴⁾ and 9-52³⁵⁾ show a system setup for fluorescence lifetime measurement and typical results that were measured. The photomultiplier tube used for this measurement is a high-speed MCP-PMT (Hamamatsu R3809U).



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Figure 9-51: TCPC system for fluorescence lifetime measurement



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Figure 9-52: Fluorescence lifetime data of stiff-stilbene (courtesy of Prof. Yamazaki, Hokkaido University, Japan)