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Results on Optical Module Calibration.

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I have been trying to calibrate the optical modules (OM's). Finally, all OM's are calibrated and the results are shown below.

To calibrate the OM's, a test scheme were set up. The pulsed nitrogen laser is used for the light source. The light is attenuated by calibrated ND filters and fed into a F/O cable. The F/O cable feeds the laser light pulse into the refrigerator, which is used as a dark and cold box. The light is diffused by a small frosted glass sphere, which is set 15 cm apart from the OM surface.

The output pulse from the OM is converted to an electronic signal by the F/O reciever. The gate pulse is generated by the output pulse from the photo diode which is monitoring the laser light before the ND filters. The gate width can be changed by software through CAMAC gate generator (LeCroy 2323). Usually 1 μ S pulses are used for the gate pulses. Using the signal from the F/O reciever along with the gate pulse, start and stop pulses for a TDC (LeCroy 2228A) are generated at the leading edge and the trailing edge of the signal to measure the OM output pulse width. Almost the same scheme is used to measure the response time of the OM's. In this case, the gate signal starts the TDC and the OM signal stops the TDC. The TDC can measure the time from a start pulse to a stop pulse up to 500 ns with an accuracy of 0.25 ns. If the time interval is expected to be longer than 500 ns, the start pulse is delayed by the other channel of the CAMAC gate generator.

Suppose that the discriminator threshold level is low enough. to efficiently pick up 1 PE signals, then the probability of getting a signal, the ratio of 1 PE to 2 PE events, etc., should be able to be calculated by Poisson statistics. Let m be a mean PE number that PMT photocathode emits, the probability of getting a signal from the OM can be expressed as

$$m = - \ln (1 - \text{Prob.}) \quad (1)$$

Because of the fact that we cannot detect a 0 PE signal, the mean PE value for the acquired data is not the same as m . Let's write it as Q :

$$Q = m / (1 - \exp (-m)) \\ = - \ln (1 - \text{Prob.}) / \text{Prob.} \quad (2)$$

The acquired data should be plotted against Q to get a real relation between PE's and the data. For the strong light pulse, it is difficult to calculate Q value only from the data because the probability of getting the signal becomes close to 100 %. The Q values for these data are estimated from the attenuation of the ND filters and largest Q value data which can be calculated from the data.

The data on the OM output pulse width against the Q value are shown in Fig-1 through 7. The vertical bar shown in the figures represents the standard deviation of the pulse width fluctuation. All the data shown are taken with HV of 10**7 gain and the threshold level of 40 mV ($\sim 1/2$ PE level). The result of the semi-log fit to the data is also shown in the figure as the dashed

curve. Excluding these data whose Q value cannot be calculated directly from the data, first four to six data points are used for the fit

The data on the OM response time is shown in Fig-8. The distribution of OM response time has a long tail, especially for the data with a weak light source. Thus the peak value is used for this plot. The time jitter is estimated from the full-width-half-maximum value of the response time distribution and is shown as the vertical bars. The response time of the OM decrease with Q value up to 10 ns. The difference of the response time between the OM's is about 10 ns.

The absolute response time of the OM is estimated to be 190 ns. 10 ns delay is expected for the amplifier and the discriminator. 25 ns delay is expected for the stretcher circuit. Another 25 ns delay is expected for the F/O transmitter and receiver pair. Thus the response time of the PMT itself is estimated to be ~ 130 ns.

Q vs Pulse Width Distribution

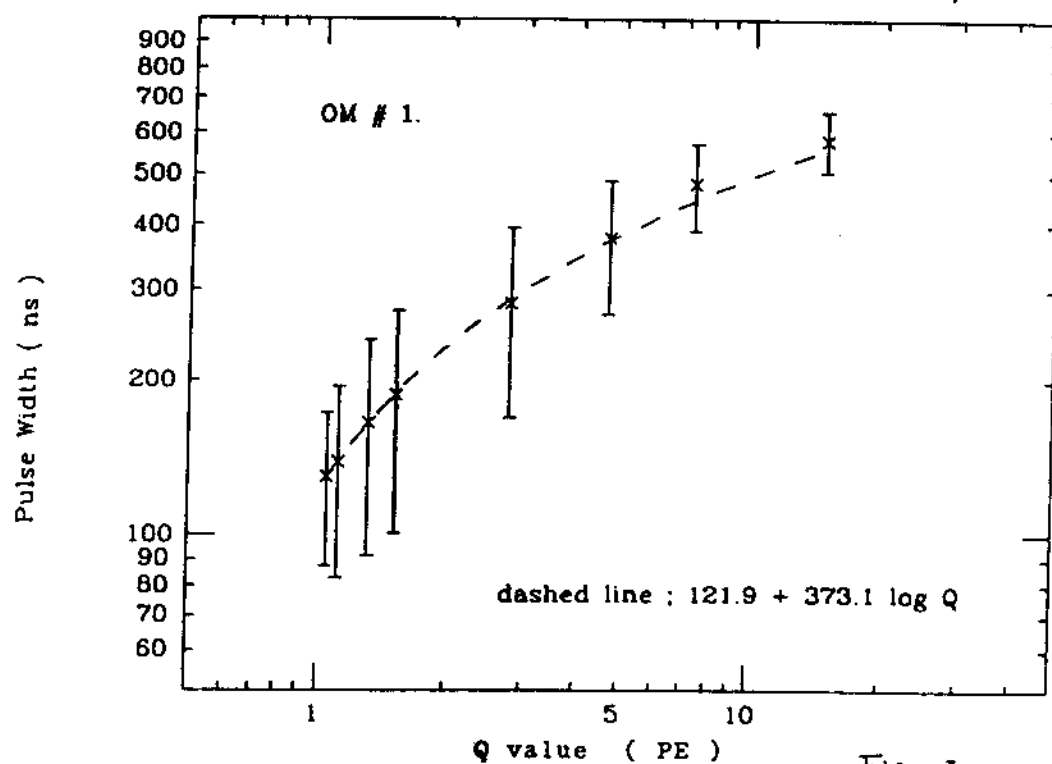


Fig - I

Q vs Pulse Width Distribution

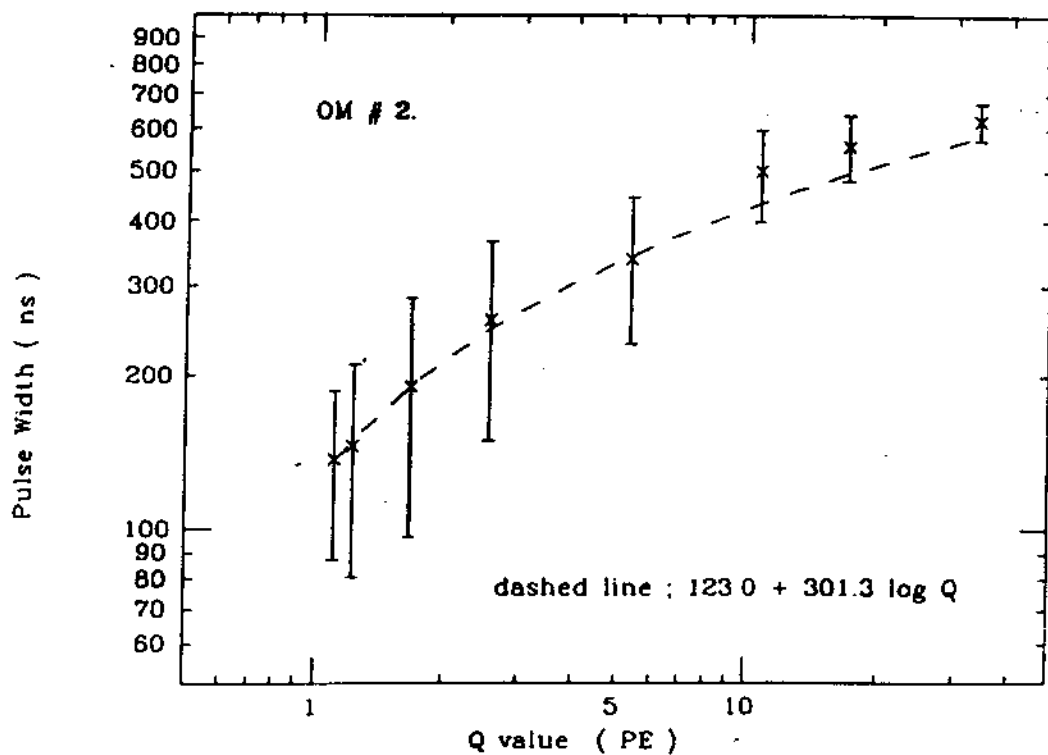


Fig - II

Q vs Pulse Width Distribution

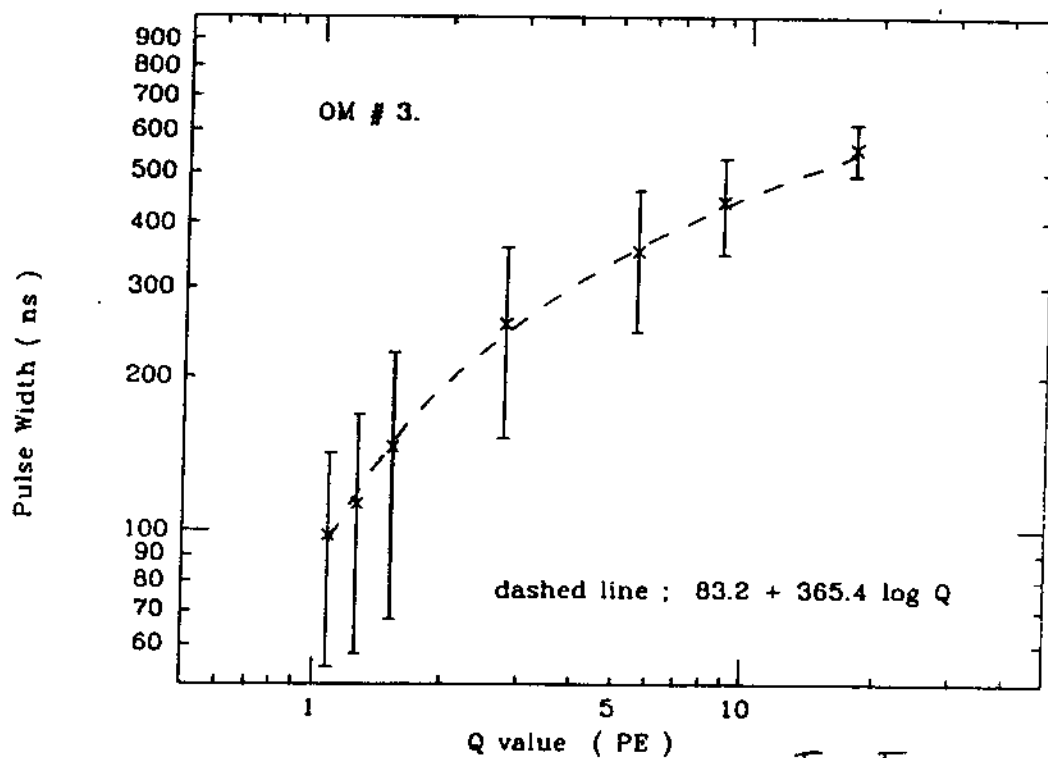


Fig - III

Q vs Pulse Width Distribution

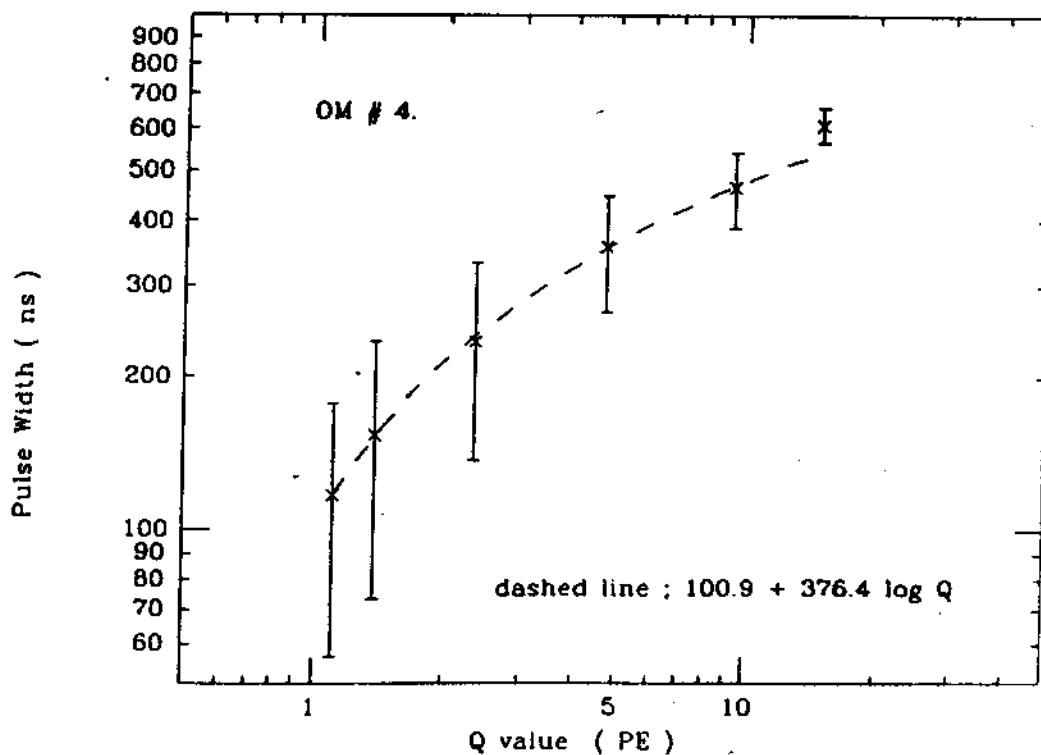


Fig - IV

Q vs Pulse Width Distribution

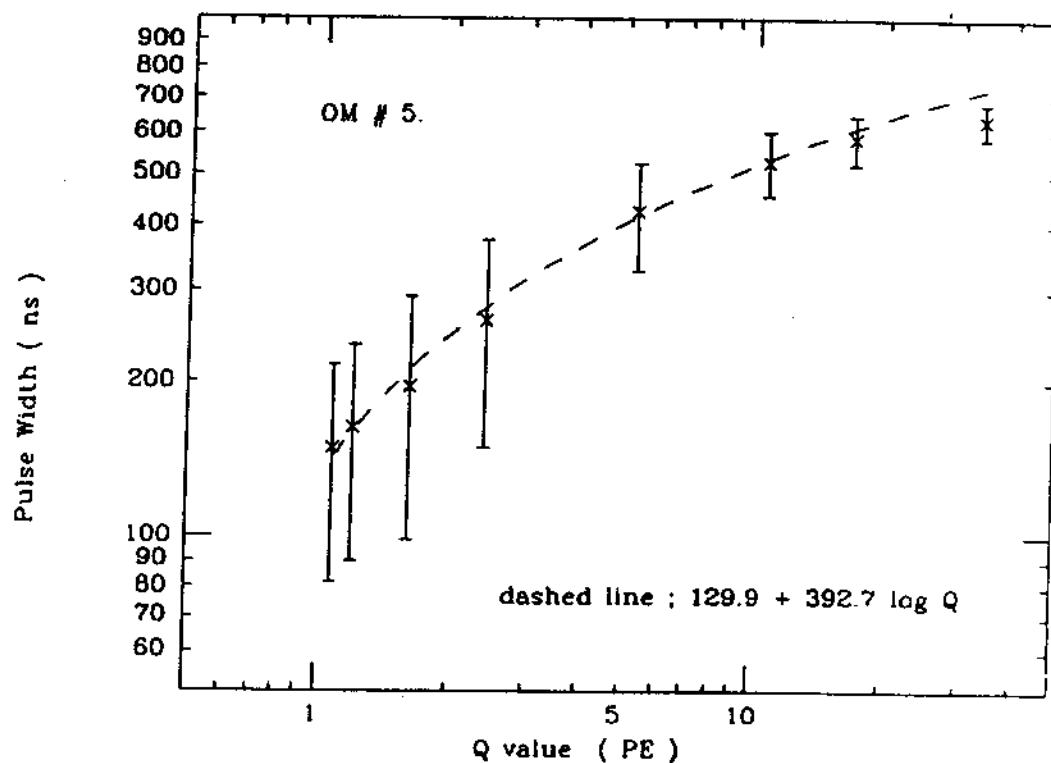


Fig - V

Q vs Pulse Width Distribution

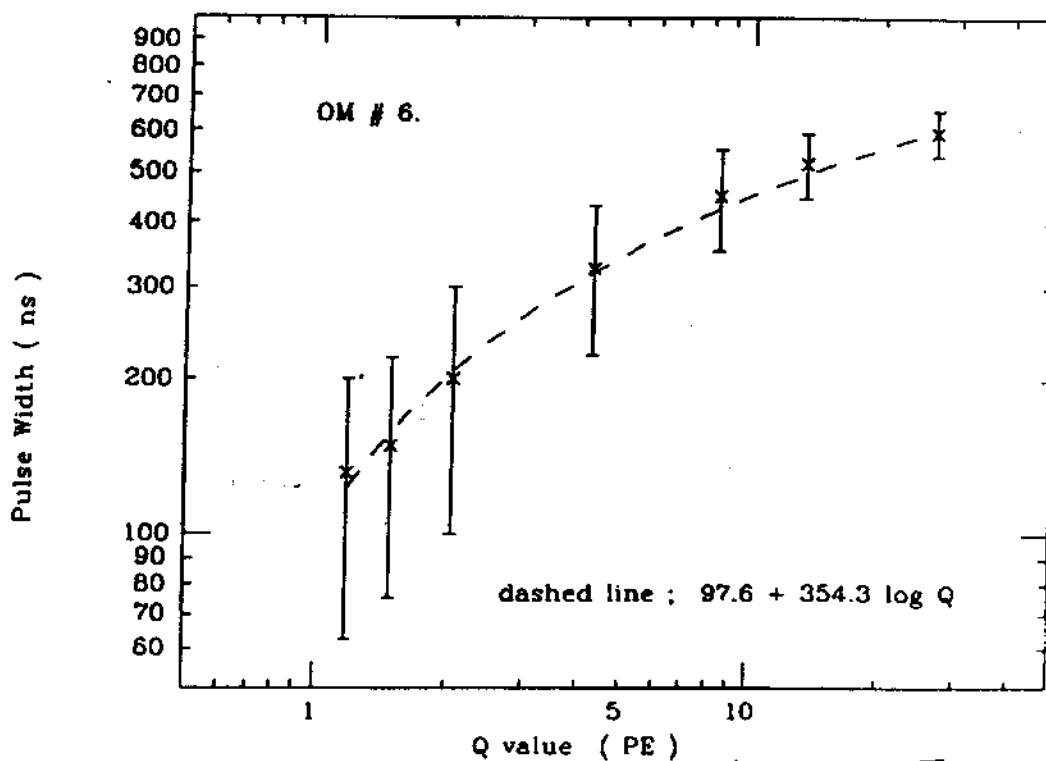


Fig - VI

Q vs Pulse Width Distribution

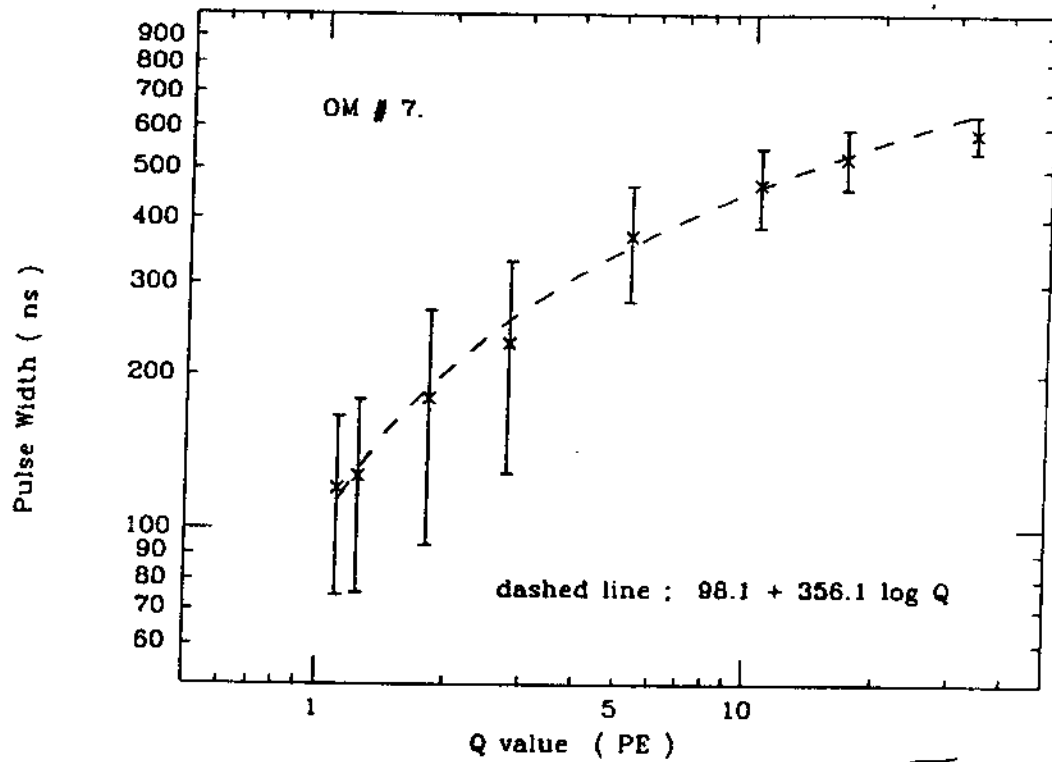


Fig-VII

Q value vs Time Delay and Jitter.

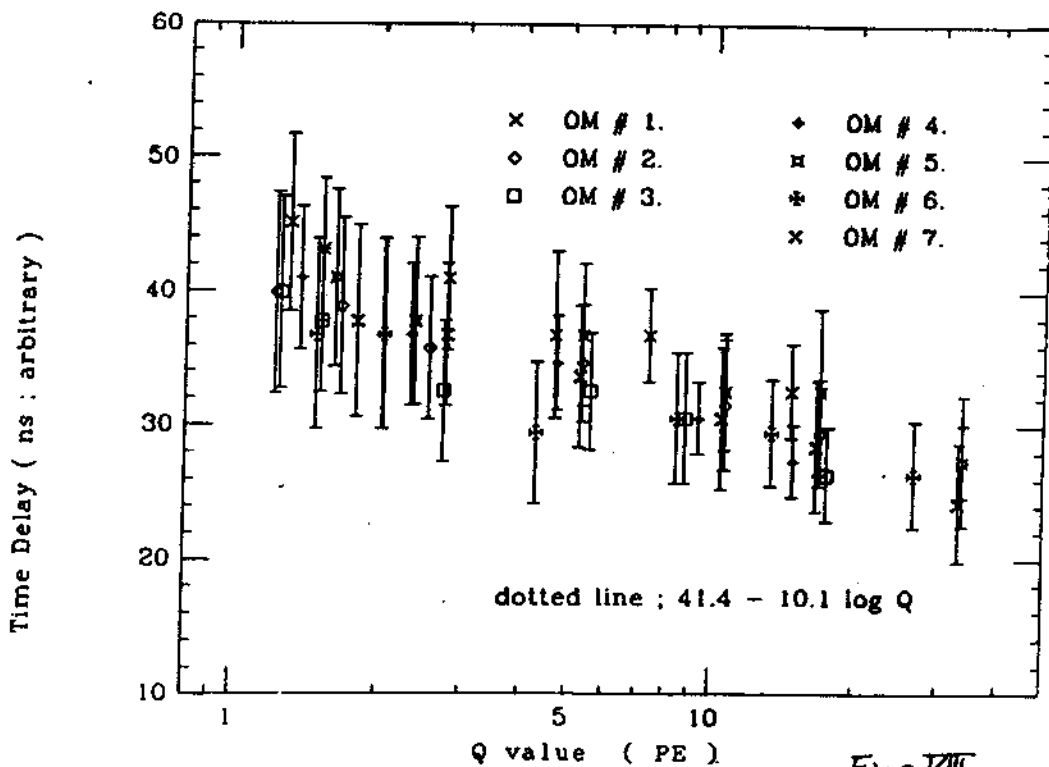


Fig-VIII