Photomultipliers

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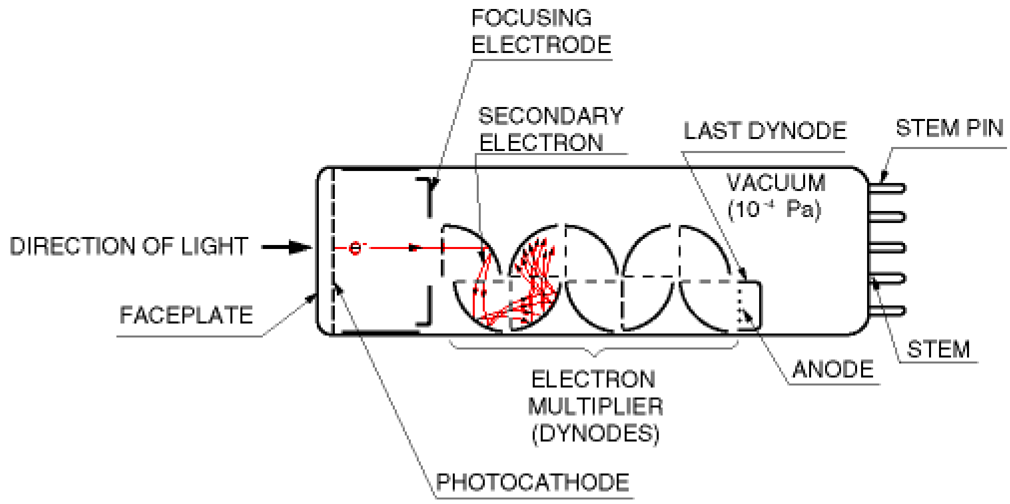
1. Equipment



Taken from Hamamatsu Corporation

The image above is a cross-section of a photomultiplier tube. The photons given off from the specimen hit the photocathode causing the release of electrons in the tube. As the result of a voltage difference between the photocathode and the first dynode the electrodes are accelerated towards the dynode, which releases a larger number of secondary electrons. This multiplication step is continued until at the end of the tube the electrons hit the anode. This current is then measured.

2. Signal analysis

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Analog mode

The amplified photocurrent is converted into a voltage and recorded. Usually the photomultiplier's current-to-voltage amplifiers produce 1V per 1 µA of amplified photocurrent. This can then be recorded using a chart recorder, with the drawback of a loss in temporal resolution. The fastest chart recorders have about a 0.1 second response time whereas PMTs have a response in the submillisecond range. The alternative is to use a digital storage oscilloscope or to digitise the output using a computer to store and analyse the signal.

All photomultipliers produce a current in the absence of light, appropriately called the dark current. This noise dictates the resolution of the photomultiplier at low light levels. An average dark current can vary between 0.03 to 10 nA (ie for 0.03 nA a voltage of about 30 µV would be recorded) depending on the model. This means that the signal to be recorded

Photon counting

When a photon strikes the photocathode it gives rise to a photocurrent at the anode which lasts only a few tens of nanoseconds. This means that if the rate of absorption is low (<10^6 /sec) individual current pulses can be detected and counted (there is very little chance that two photons will coincide).

The current pulses measured are not uniform but rather have a distribution depending on their wavelength. This means that the output signal can be sent through a discriminator, which filters out pulses above and below a range set by the experimenter. This effectively screens out the noise and as a result photon counters have dark counts of a few per second at room temperature, less if the tube is cooled. For example a good photomultiplier has a dark current of 1800 photons/second but a photon counter would reduce this to <10 photons/second. Once collected the pulses can be shaped and counted

3. Links

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Electron tubes

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