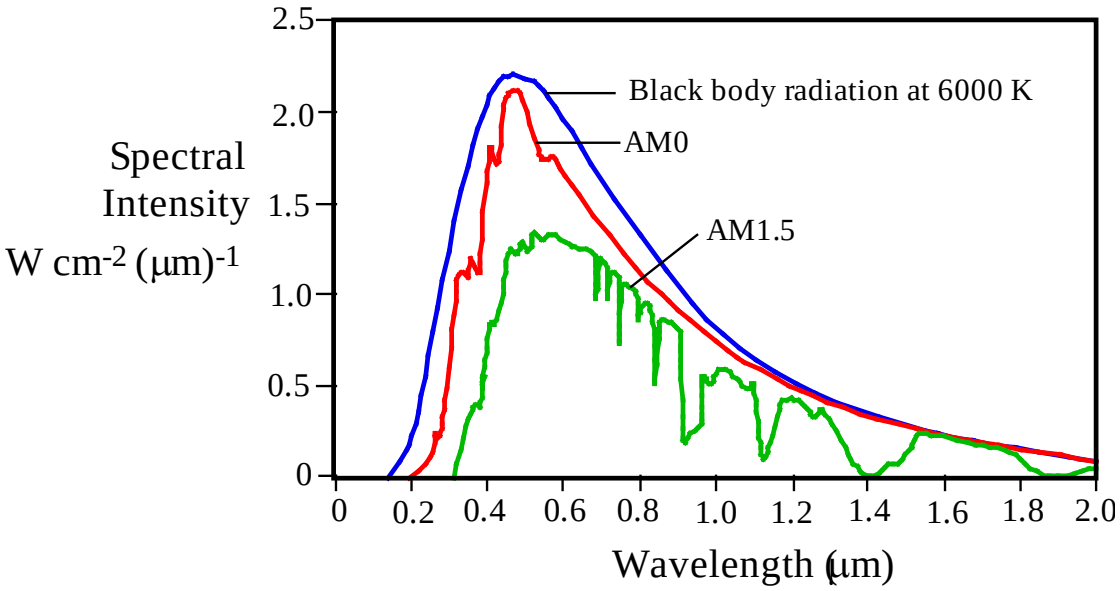
Photovoltaic Solar Cells

→ A photodiode optimized for the solar spectrum



The spectrum of the solar energy represented as spectral intensity (I_λ) vs wavelength above the earth's atmosphere (AM0 radiation) and at the earth's surface (AM1.5 radiation). Black body radiation at 6000 K is shown for comparison (After H.J. Möller,*Semiconductors for Solar Cells*, Artech House Press, Boston, 1993, p.10)

Photoemissive Photodetectors

The Basic Idea

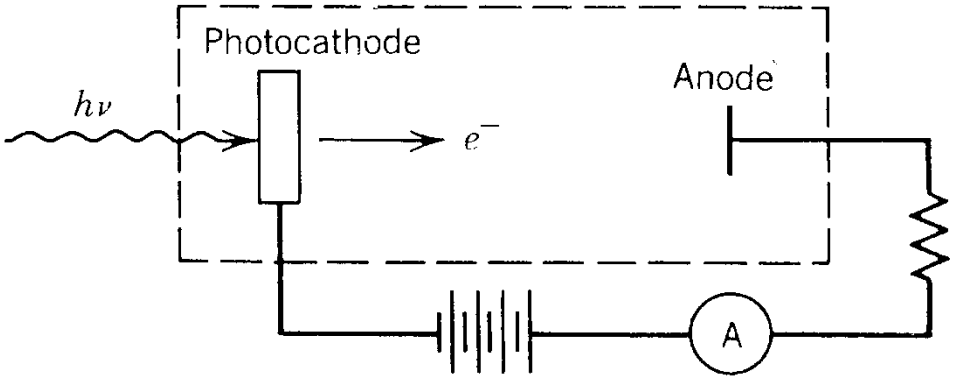


Figure 5-1 Photoemissive detection.

From Optical Radiation Detectors, Dereniak and Crowe

Photomultipliers

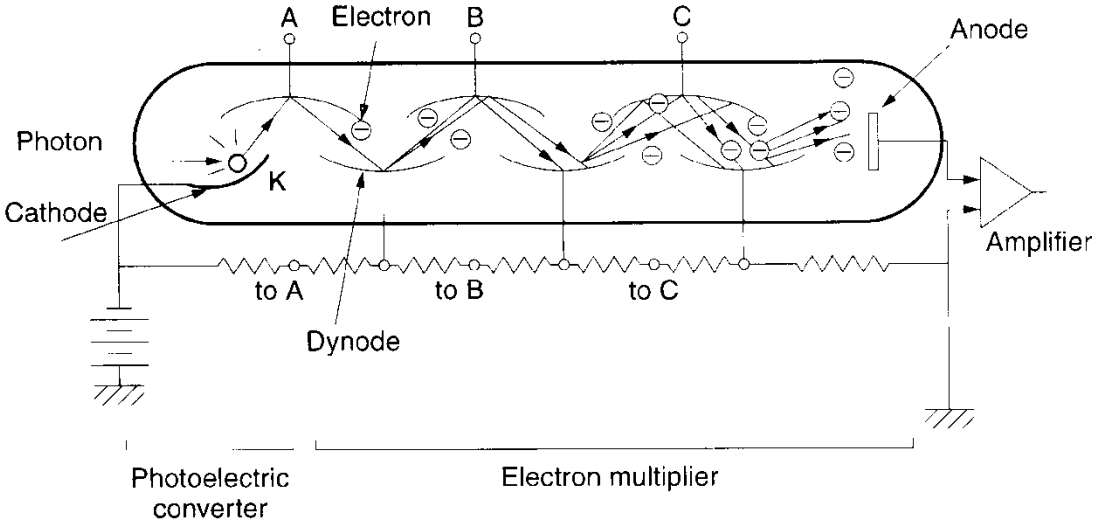


Figure 12.1 Photomultiplier tube. Points A, B, C . . . at the bottom are connected, respectively, to the A, B, C, . . . dynodes at the top.

Responsivity:

Photomultipliers can have very large gain G ~ 10^5, so the responsivity is also large, R ~ 10^4 Amps/Watt

Spectral Response: → Visible and near infrared

Table 5-1

Cathode	Composition	λ_p (μm)[a]	η (λ_p)
S-1	AgOCs	0.8	0.004
"S"	Cs_3Sb	0.38	0.16
S-10	BiAgO Cs	0.42	0.068
S-11	Cs_3Sb-O	0.39	0.19
"Super" S-11	CsSb-O	0.41	0.23
S-20	Na_2KSb-Cs	0.38	0.22
Bialkali	K_2CsSb	0.38	0.27
"High Temp" Bialkali	Na_2KSb	0.36	0.21

[a] Assumes that a glass window is used.

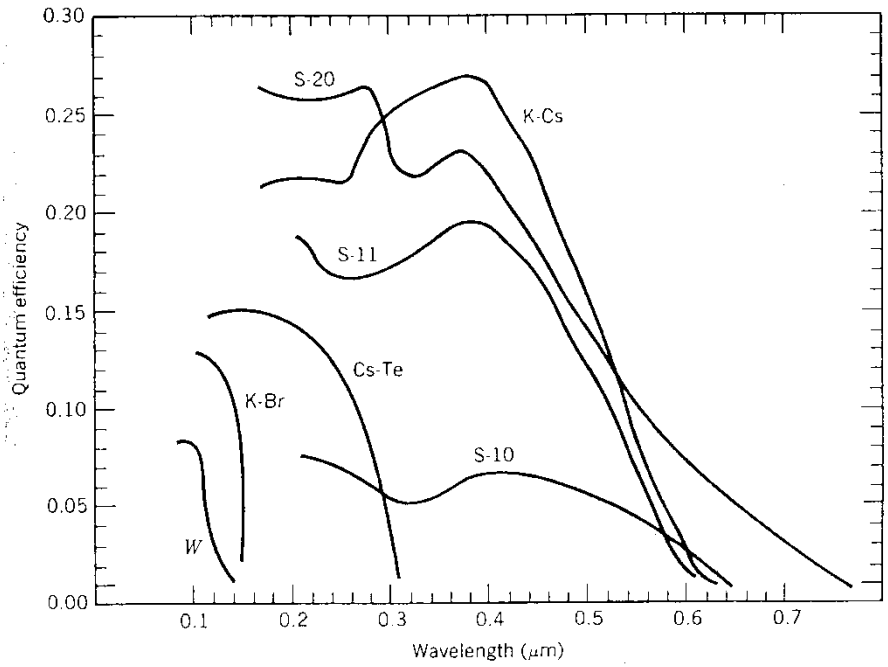


Figure 5-2 Spectral response of photocathodes.

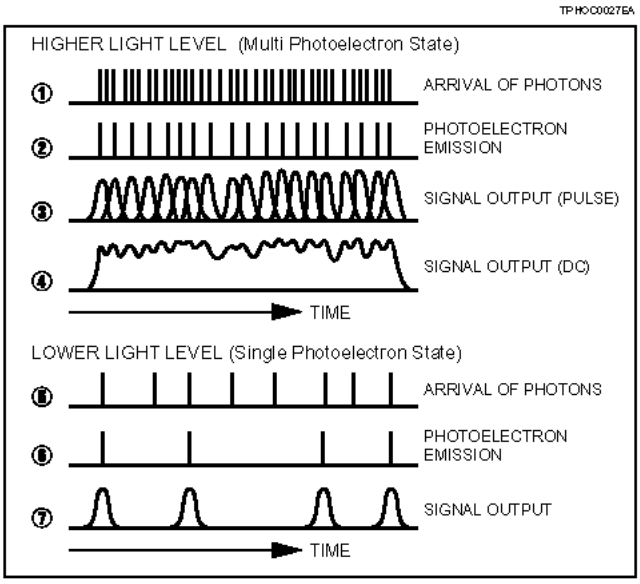
From Optical Radiation Detectors, Dereniak and Crowe

Sensitivity:

→ Good for very low-level light (commonly used in photoluminescence set-ups)

High gain means photomultipliers can be used to detect individual photons.

Figure 1 : Output Pulses from Photomultiplier Tube at Different Light Levels



From Hamatsu Photomultiplier Handbook

High gain in the photomultiplier makes the voltage pulses due to individual photons larger than the background noise. Because the photomultiplier is often used for photon counting, D^* values are usually not quoted.

Temporal Response for Photomultipliers:

→ ~ 5 nanoseconds, limited by spread in photoelectron transit times

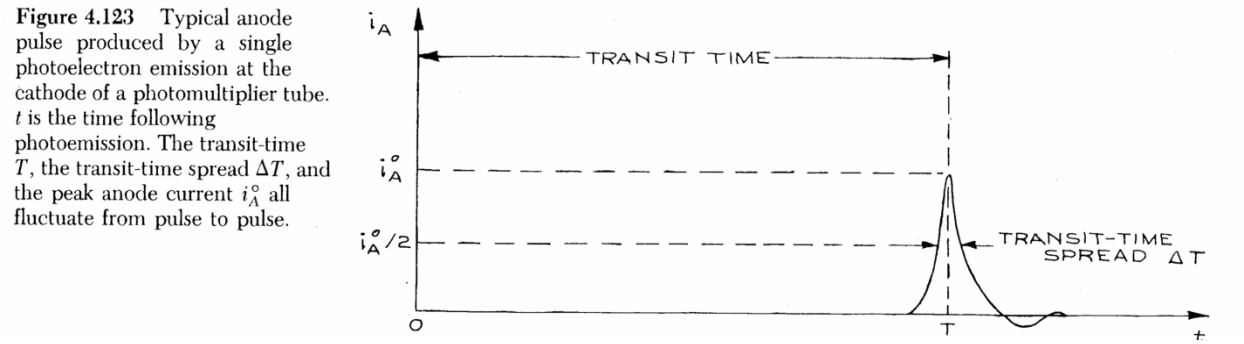
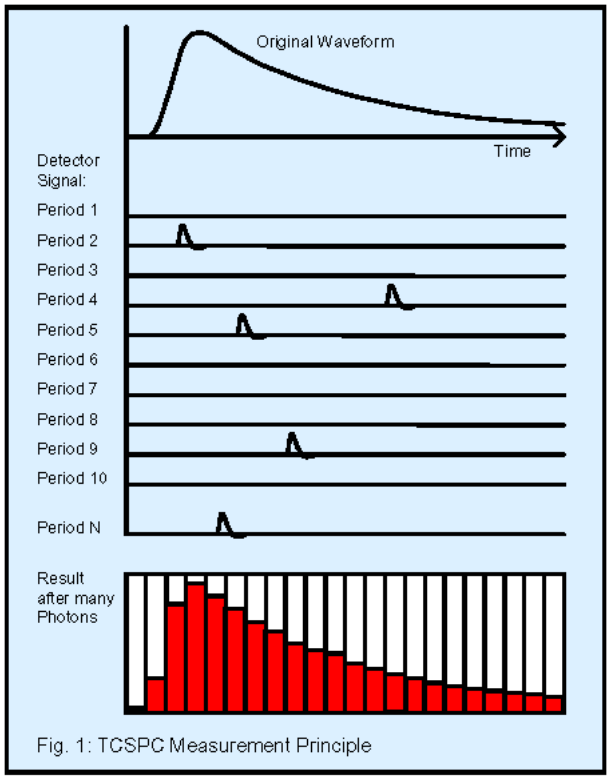


Figure 4.123 Typical anode pulse produced by a single photoelectron emission at the cathode of a photomultiplier tube. t is the time following photoemission. The transit-time T, the transit-time spread ΔT, and the peak anode current i_A° all fluctuate from pulse to pulse.

From Building Scientific Apparatus, Moore et al.

Time-Resolved Photon Counting:



From web site of Photonic Solutions PIC.

Microchannels:

For faster photomultipliers (response time ~ 200 psec) that can be made into arrays use microchannels.

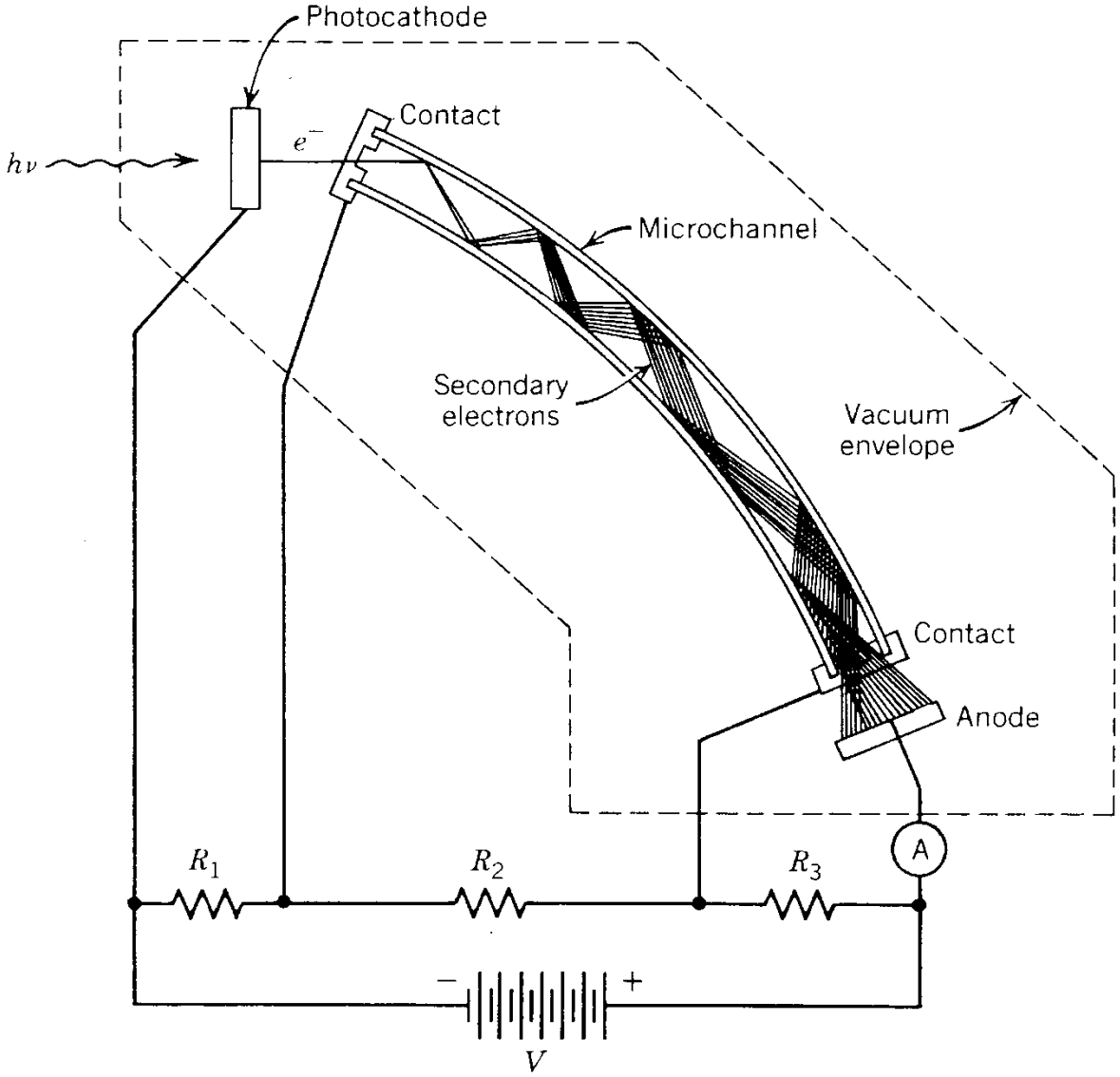


Figure 5-7 Photodetection utilizing microchannel electron gain.

From Optical Radiation Detectors, Dereniak and Crowe

Streak Cameras (Time resolution can be 500 fsec.)

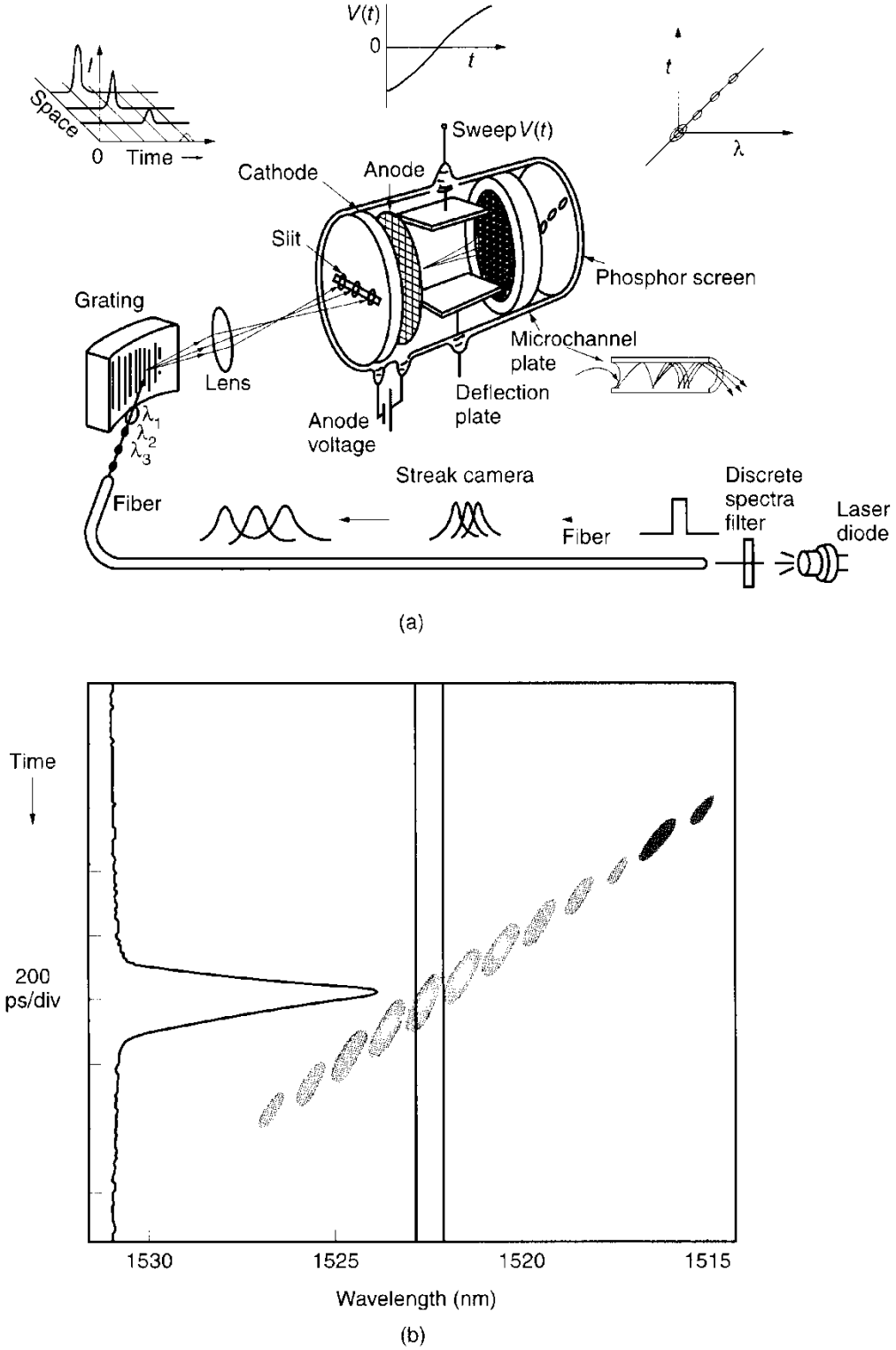


Figure 12.2 Streak camera measuring (a) the dispersion during transmission in an optical fiber and (b) chromatic dispersion in single-mode optical fiber. (After Y. Tsuchiya [1].)

from Elements of Photonics, Iizuka