

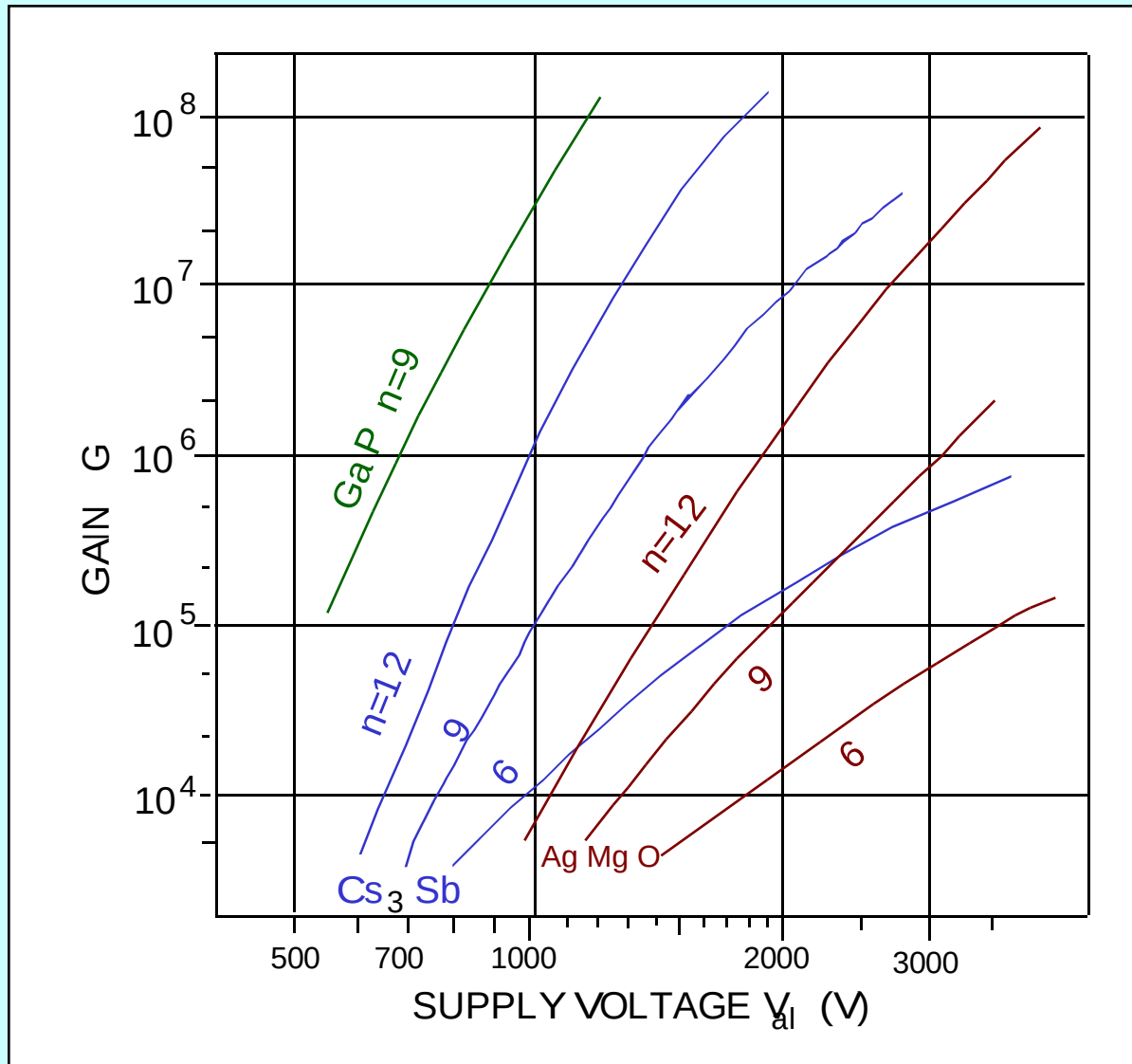
Photocathodes

All the photocathodes *responses* (S-1, S-11, S-20, S-20 ERMA) are available, with the various options for the optical access window and UV cutoff.

Photocathode *formats*: tubes with 12, 18, 25, 38, or 50 mm diameter are currently available. Special devices can reach 200 and 500 mm diameter with hemispherical surfaces or a hexagonal shape suitable for side-by-side packing. Special units with unusually large sizes are fabricated for physics.

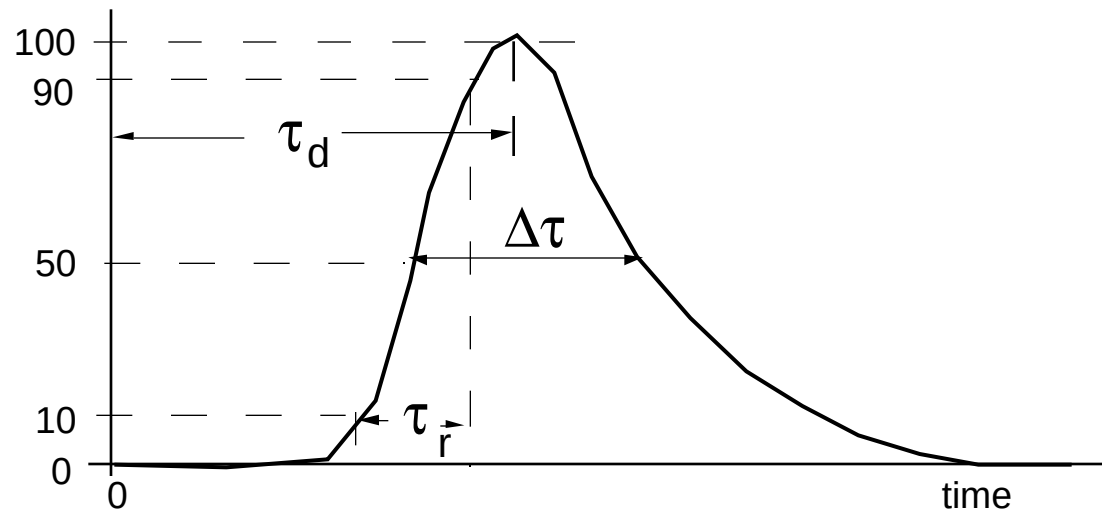
It is advisable to select the smallest photocathode *area* required by the application, to minimize size, cost, and dark current.

Number of dynode and gain



Gain of the PMT
vs total supply
voltage for some
commonly used
materials and
number of stages

SER waveform and parameters

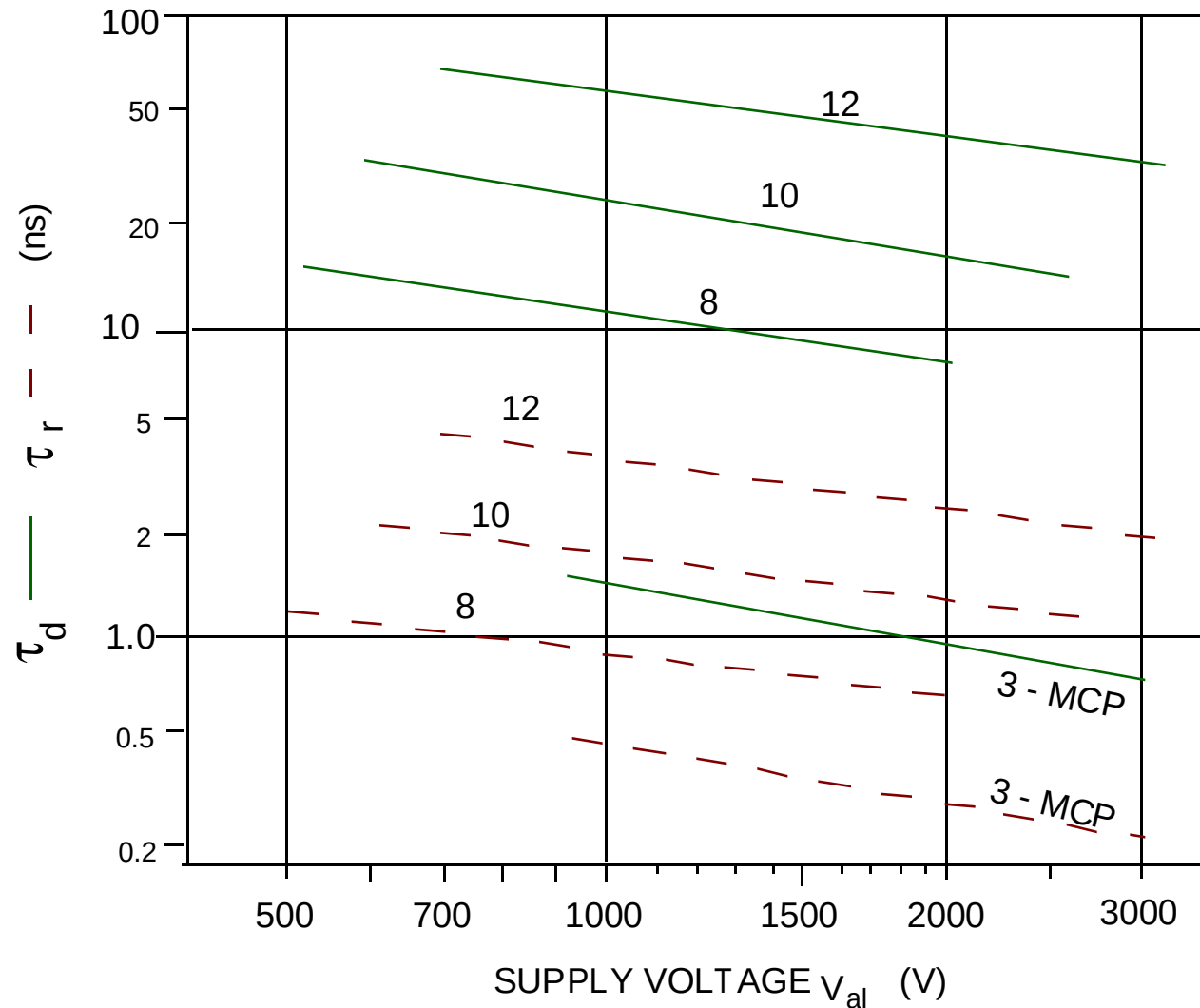


Time parameters of the SER characteristic :
delay time τ_d , *duration* $\Delta\tau$ and *rise time* τ_r

for a Gaussian waveform with variance σ_T :

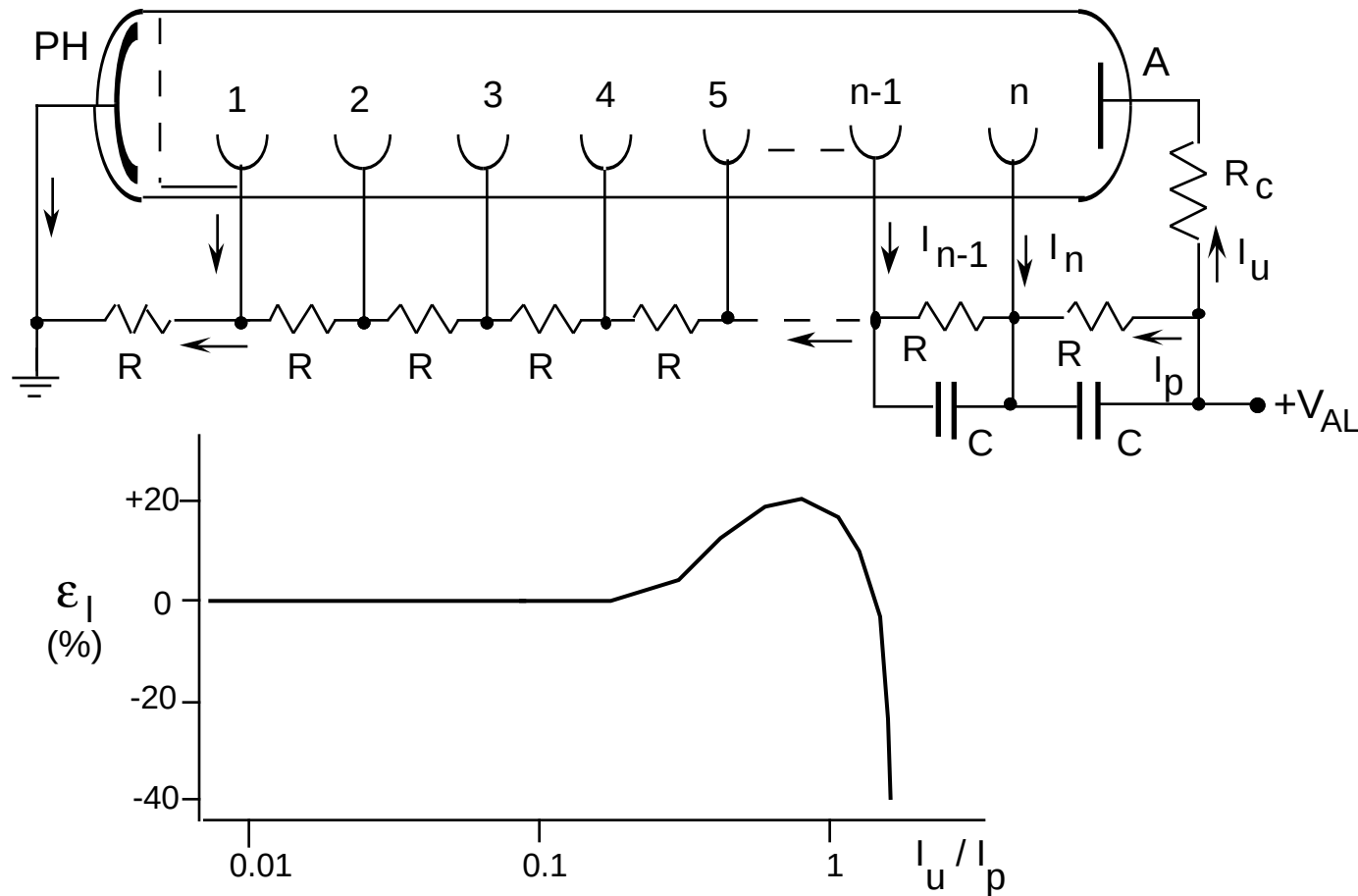
$$\Delta\tau = 2.36 \sigma_T, \quad \tau_r = 1.49 \sigma_T, \quad f_{[3\text{dB}]} = 0.83 / (2\pi \sigma_T)$$

SER waveform and parameters (cont'd)



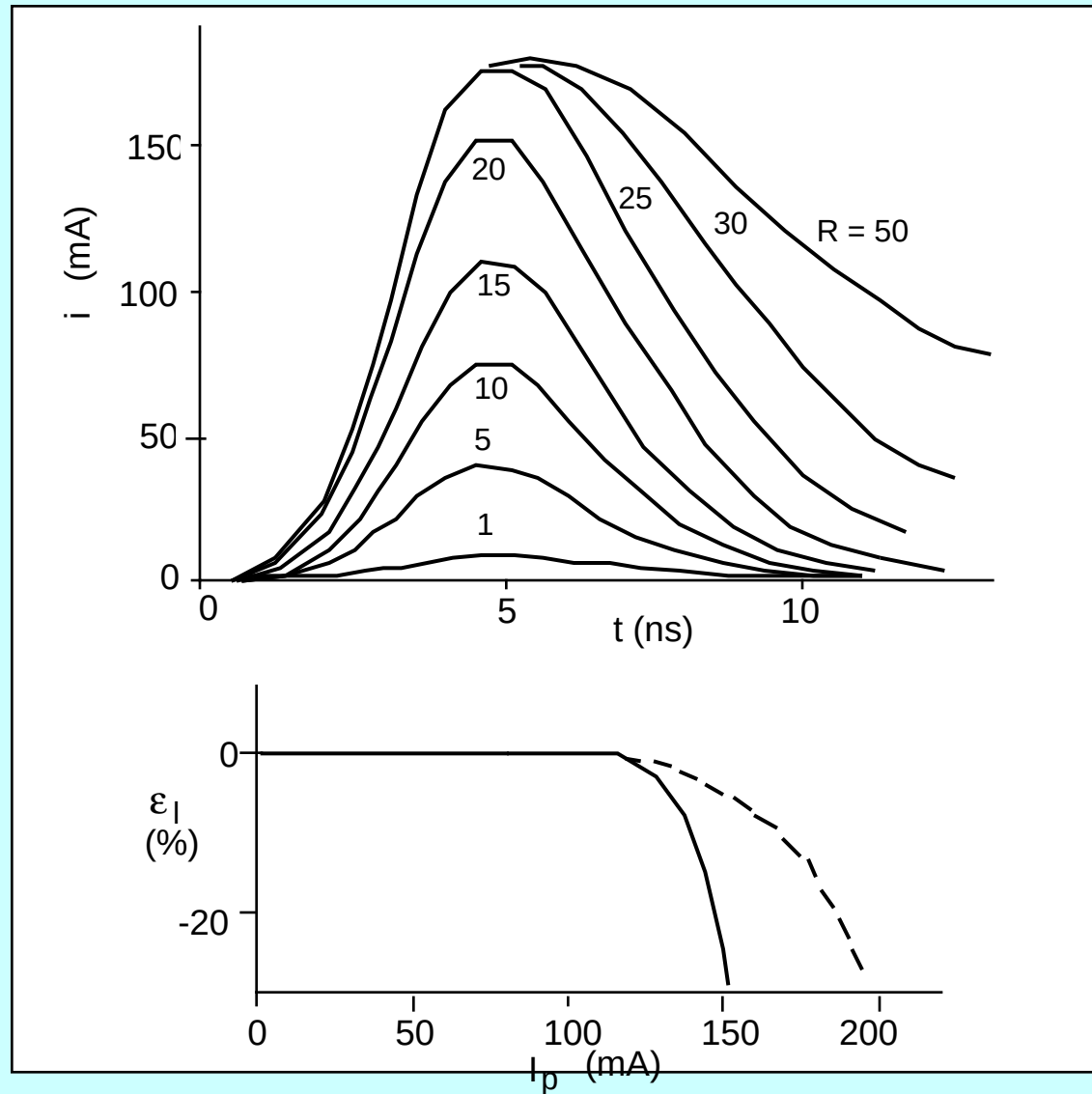
SER delay time τ_d , duration $\Delta\tau$ and rise time τ_r vs supply voltage, with the number of dynodes as a parameter

Linearity and saturation (dc)



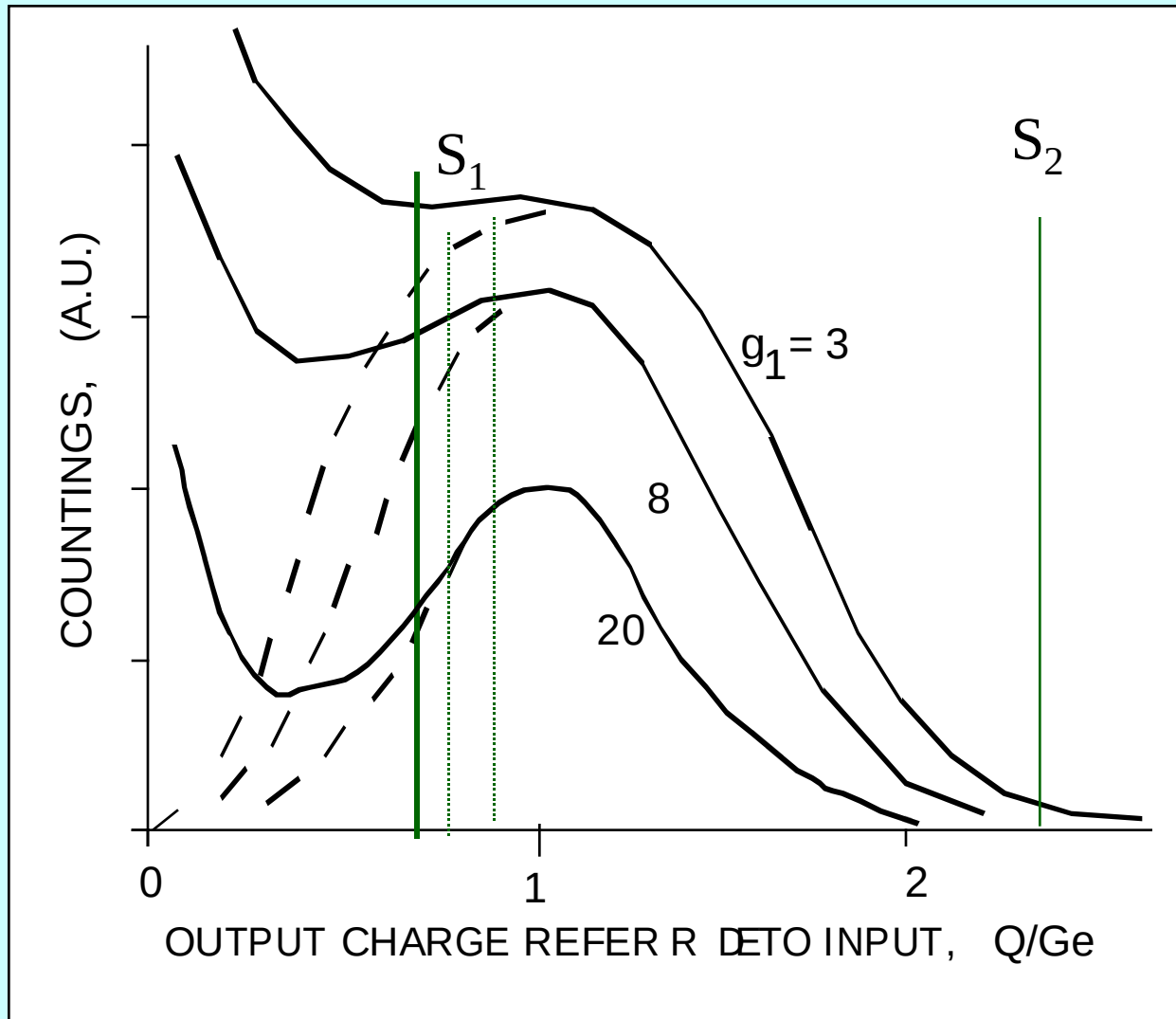
dynode voltage divider and linearity error in dc current near saturation (bypass capacitor are for ac linearity)

Number of dynode and gain



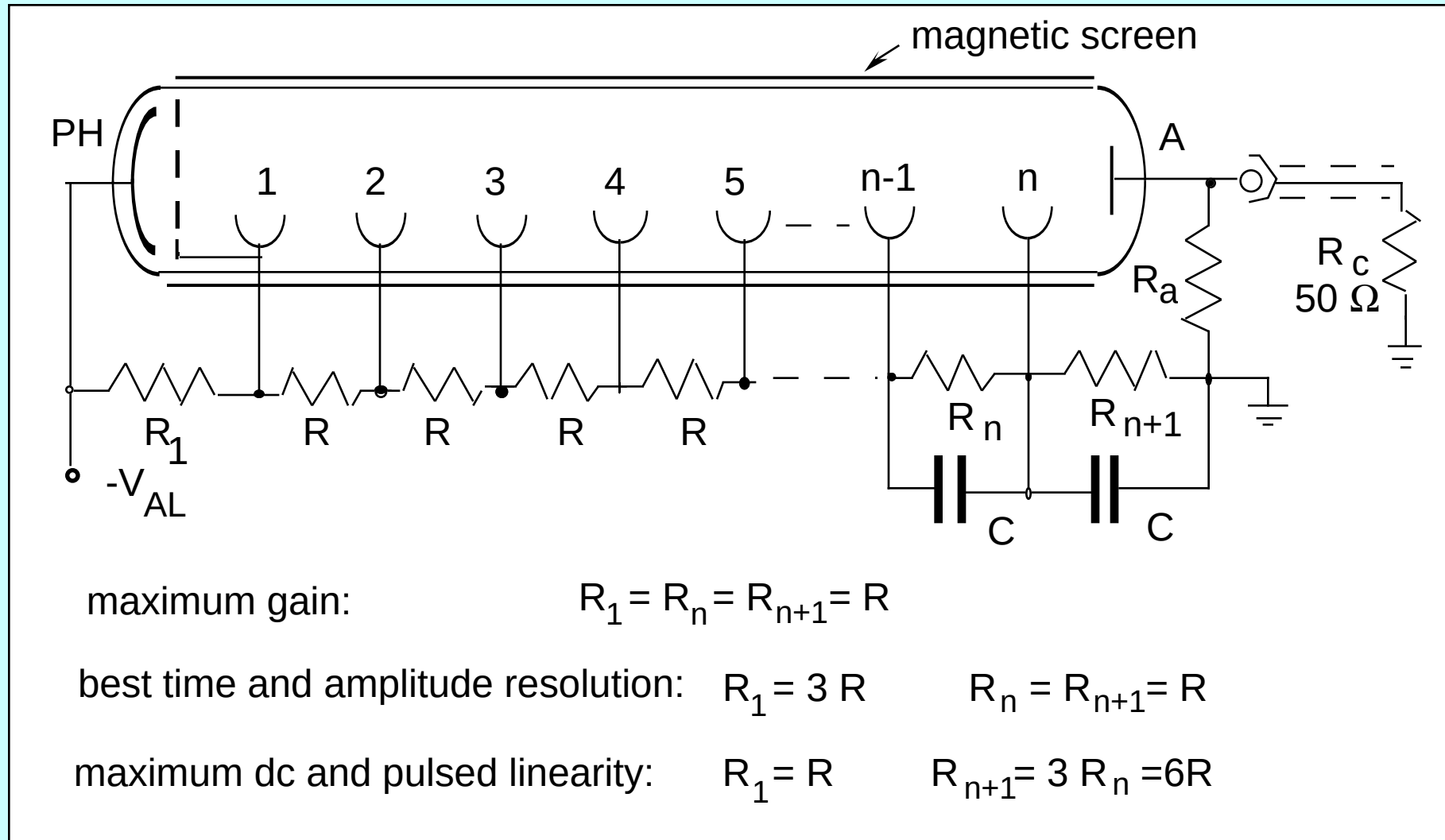
distortion of the current output pulse at increasing number of photoelectrons R per pulse (top), and linearity errors (bottom) of the pulse peak (full line) and of the total charge (dotted line)

Dark current pulses distribution



distribution of the output charge Q for three values of the 1st dynode gain g_1 (curves not to same scale) Increase near $Q = 0$ is the contribution of dark current from dynodes, subtracted in dotted line curves.

Choice of PMT bias circuit



Hysteresis and drift

Upon PMT supply voltage (HV) switch-on:

- gain and dark current transient (lasting 1-30 min., typ.)
with swings up to 50% and a decade, respectively

reason: (charge accumulated on insulating elements hit by electrons lost by the electrodes).

Upon strong changes of the photocathode illumination or of electrode HV:

- hysteresis of gain, with drifts up to $\pm 10\%$ on a minutes period

Upon strong illuminations and high gains, bringing the anode current in the range 1-10 μA :

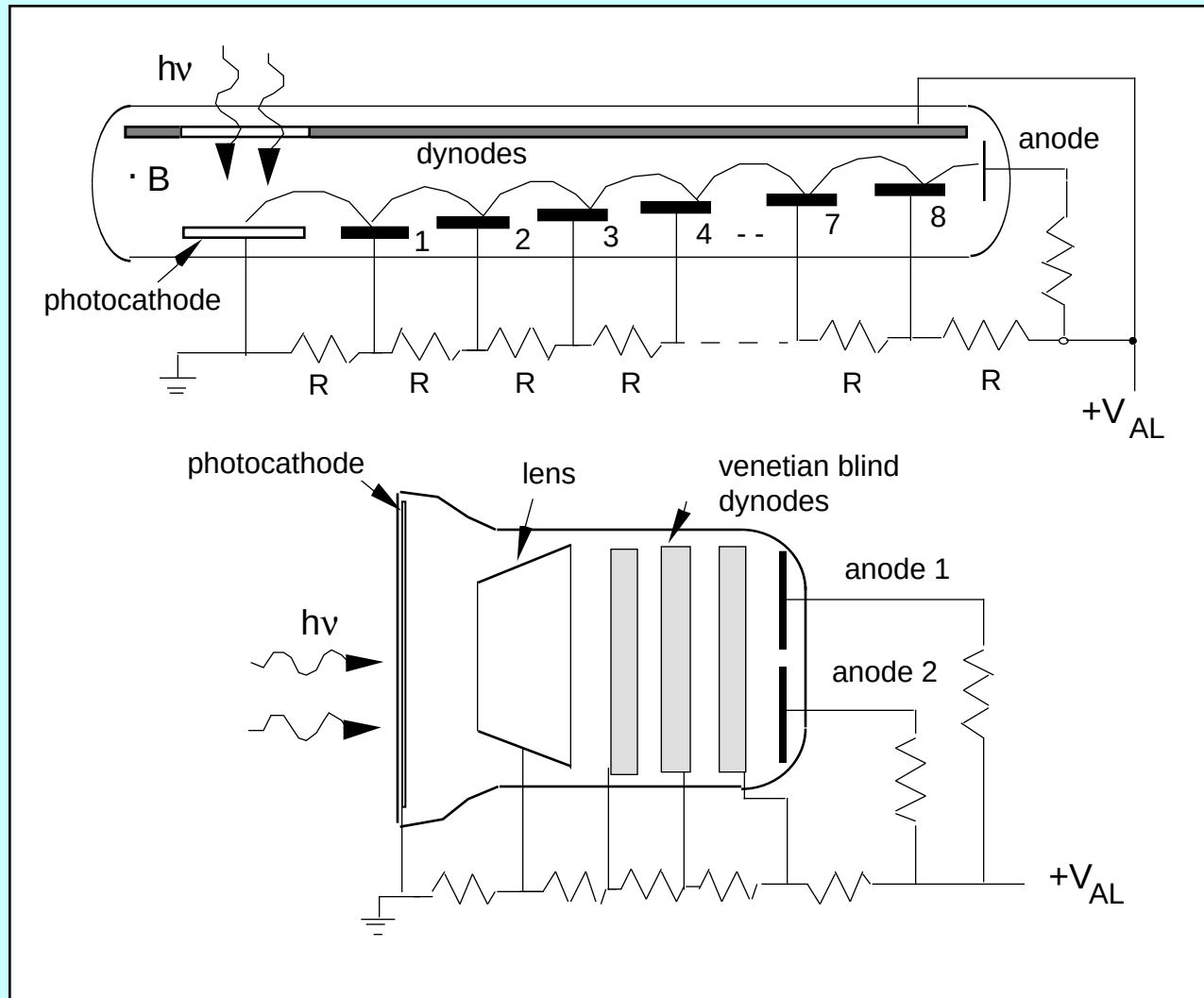
- fatigue effects show up in a time period of 10^2 - 10^3 hours,
with a progressive (but reversible) decrease of gain

Upon operation in a He rich atmosphere:

- irreversible degradation because of ion bombardment of the photocathode at HV switch-on

Warning of leak problem: (i) an unexpected increase of G due to the ionization-assisted multiplication; (ii) afterpulses following the true photodetected ones.

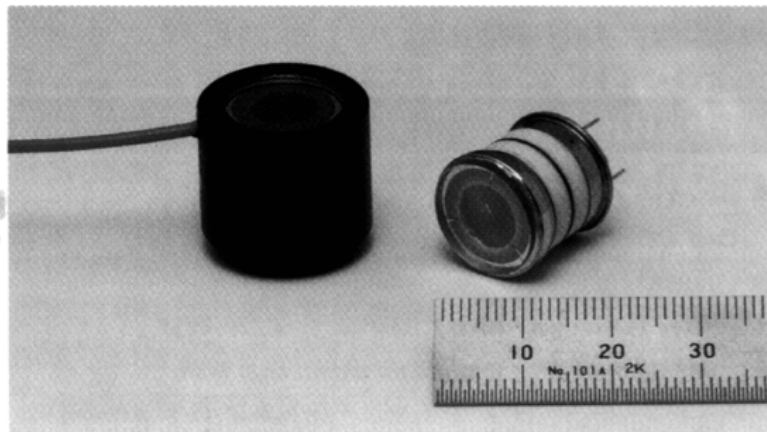
Special PMTs



Crossed-field
photomultiplier
and multianode
photomultiplier,
exemplified for
 $n=2$ (bottom)

Special PMTs (2)

R 7100U and R 7110U are the newly developed series of Hybrid Photodetectors which are very compact; in fact a minimum effective area of 8 mm dia. is enclosed in a package of 20 mm dia, 17 mm height and 13.8 g weight.



R 7100U

- 7 mm dia Single Element Electron Bombarded Silicon Diode
- Diode Leakage Current: 3 nA max.
- Diode Capacitance: 15 pF typ
- Gain: 1,000
- Time Response: 2.4 ns typ

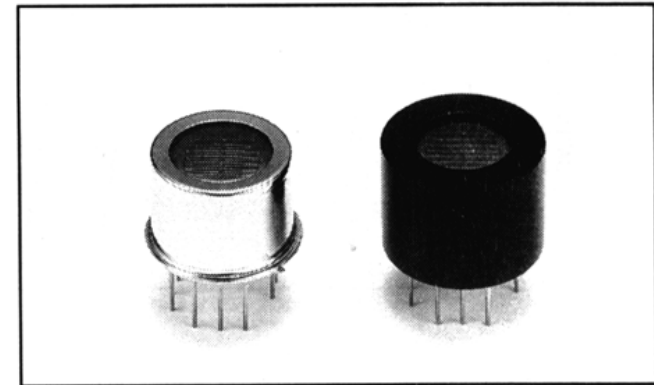
PMT with
eb-Si target

Special PMTs (3)

Ultra Compact TO-8 Metal Can Type 10mm Length, 15mm Diameter, Head-On Type

FEATURES

- “METAL PACKAGE PMT” the world smallest photo-multiplier tube in a TO-8 metal can
(1/7 size volume compared to Hamamatsu R647)
New generation of optical detector having the photo-multiplier tube performance in a TO-8 size metal can.
- Newly developed “Metal Channel Dynode”.
Applying a thin layer, “Metal Channel Dynode” developed to make timing characteristics and linearity better.

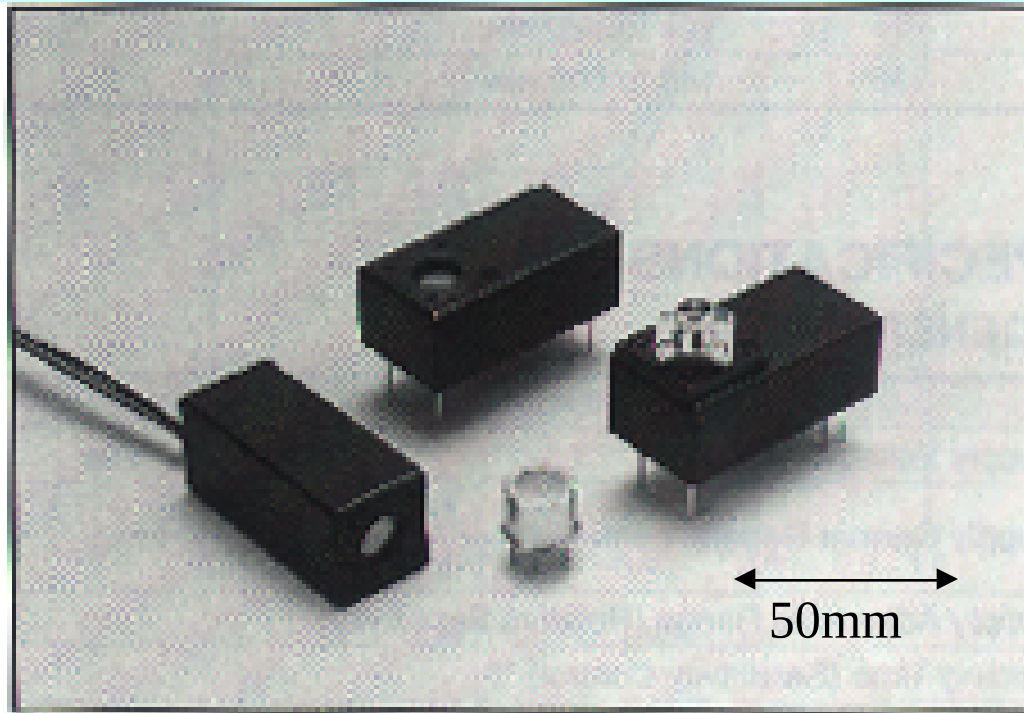


▲Left: R5600, Right: R5600U

GENERAL

Parameter		R5600/R5600U	-01	-03	Unit
Spectral Response		300 to 650	300 to 820	185 to 650	nm
Photocathode	Material	Bialkali	Multialkali	Bialkali	—
	Minimum Effective Area	8			mm dia.
Window Material		Borosilicate		UV glass	—
Dynode	Structure	Metal channel dynode			—
	Number of Stages	8			—
Case		TO-8 metal can			—
Weight		Approx. 4.1			g

Special PMTs (4)



PMT modules have 10^6 gain, 1 ns risetime
12V, 10 mA supply