PMT Data Analysis

October 7, 2002 N. Kitamura SSEC / UW

This document discusses the parameter space of PMT operation in the case of the so-called "classical base design", in which the first dynode voltage varies proportionally to the cathode-to-anode voltage.

Definition:

V1 = First dynode voltage
VG = First-dynode-to-anode voltage
Va = V1 + VG = Cathode-to-anode voltage
p = V1 / Va = First dynode voltage fraction (0 < p < 1)

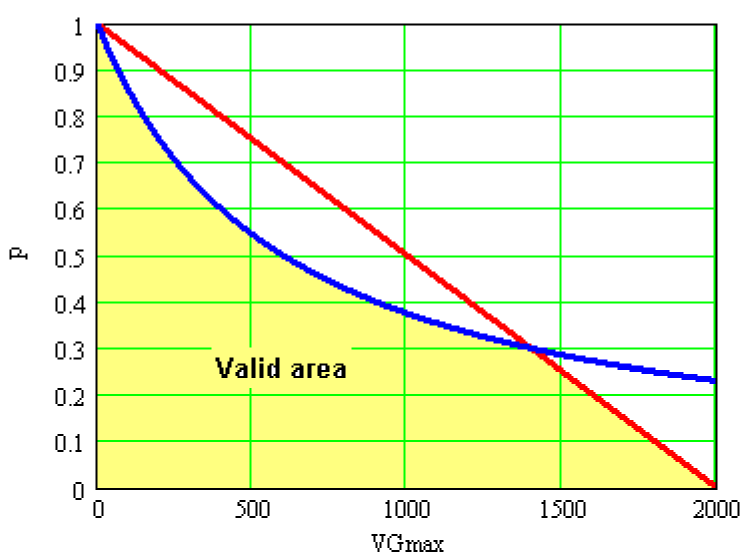
We want to be able to adjust the PMT gain over a certain range by varying Va while maintaining the minimum P/V ratio of 2.2 without exceeding the maximum voltage specification.

Constraints set by the PMT specification:

Va < Va_max = 2000 (1)
V1 < V1_max = 600 (2)

Further constraints from performance requirements:

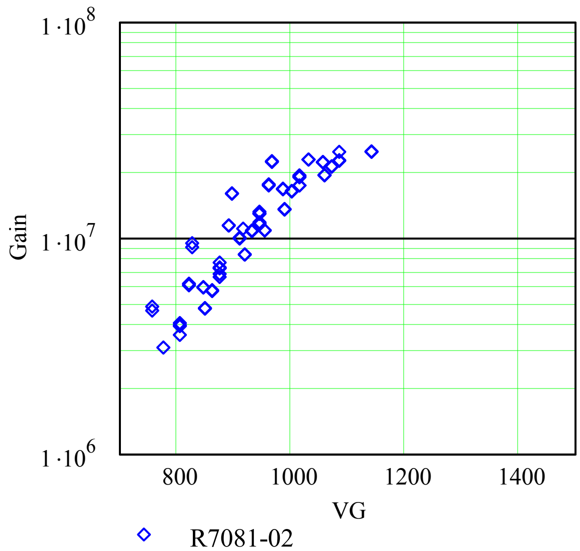
VGmin < VG < VGmax (Gain range: $5x10^6$ ~ $5x10^7$) (3)
V1 > V1min (P/V ratio>2.2) (4)



$$f(x) := 1 - \frac{x}{2000}$$

$$g(x) := \frac{600}{x + 600}$$

Figure 1 p vs VGmax



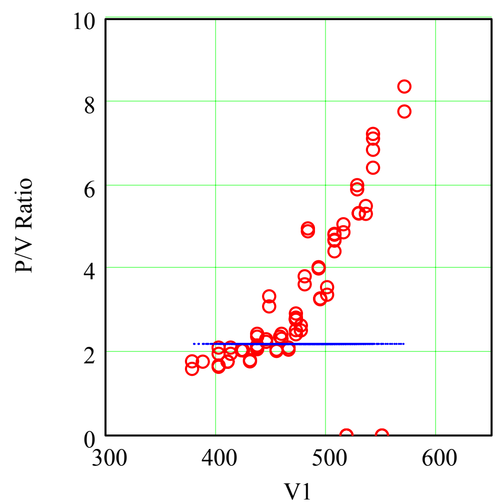


Figure 2 Gain vs VG (R7081-02)*

Figure 3 P/V Ratio vs V1 (R7081-02)*

*PMT data by K. Hanson, B. Hughey, and A. Gassner, UW-Madison, Physics.

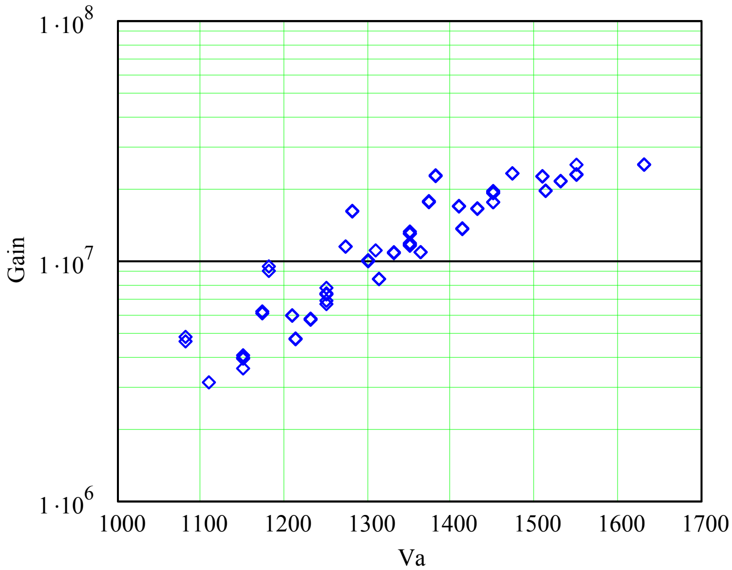
Hamamatsu R7081-02 is a 10-stage PMT with a nominal gain of 10^8.

The gain data for R7081-02, do not go beyond $2x10^7$. If we let VGmax = 1100, p is limited to the range of $p < 0.353$, according to Figure 1. Figure 3 shows that V1min=480 may be acceptable. We also have a constraint derived from the above relationships:

$$\mathrm{VGmin} > \mathrm{V1min} \cdot \left(\frac{1}{p} - 1 \right)$$

Since we want VGmin to be as small as possible, we should maximize p. We have, for example, p=0.35 and VGmin=891. These results translate to 1371 < Va < 1692.

Going back to Figure 2, we find that VGmin=891 gives a minimum gain of approx. 8x10

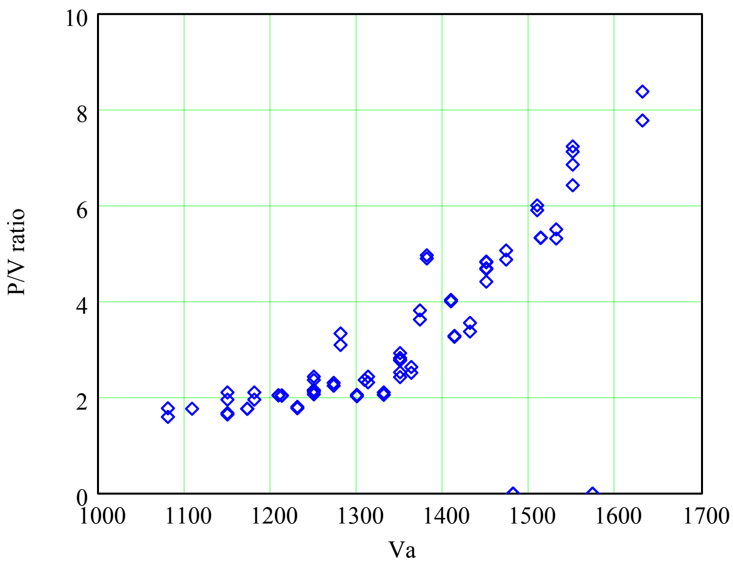


R7081-02

1371 < Va < 1692

Max Va is set by max V1=600.
Min Va is set by min V1=450.

Figure 4



R7081-02

1371 < Va < 1692

p = 0.35

Figure 5

*PMT data by K. Hanson, B. Hughey, and A. Gassner, UW-Madison, Physics.

For **R7081-01**, we may set

R7081-01=10-stage, 10^7 nom. gain.

$$VGmax := 1300$$

which limits the range of p to be

$$p < 0.316$$

Also the data indicates that we may set

$$V1min := 500$$

We have

$$VGmin > V1min \cdot \left(\frac{1}{p} - 1\right)$$

In order to minimize VGmin, we want p to be as large as possible. So let

$$p := 0.31$$

Then, we have

$$VGmin > 1113$$

The range 1113 < VG <1300 with p=0.31 translates to
1613 < Va < 1884

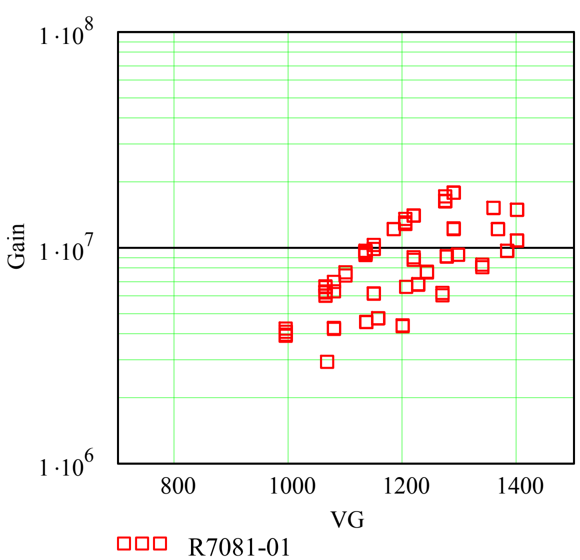


Figure 6

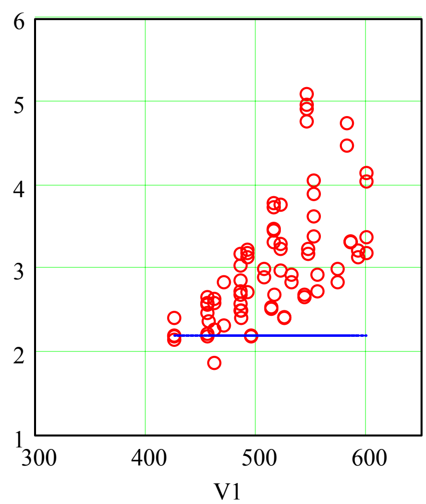


Figure 7

*PMT data by K. Hanson, B. Hughey, and A. Gassner, UW-Madison, Physics.

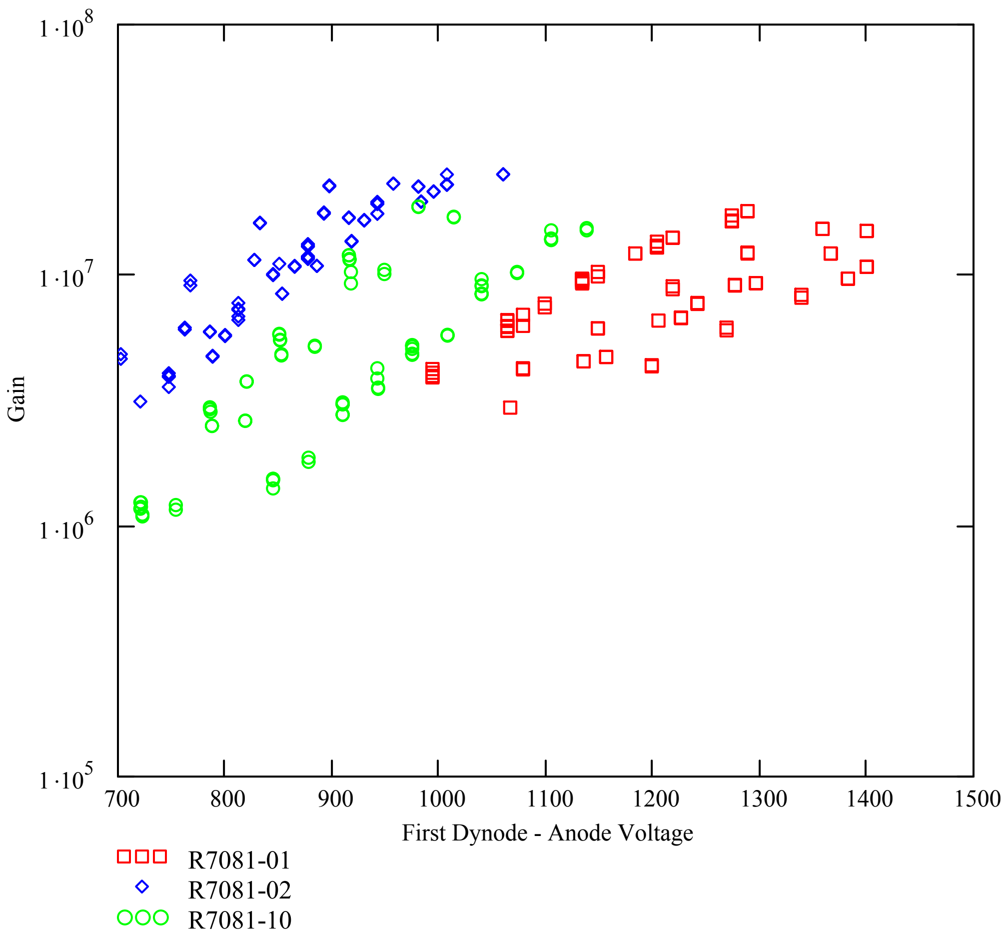


Figure 8

*PMT data by K. Hanson, B. Hughey, and A. Gassner, UW-Madison, Physics.

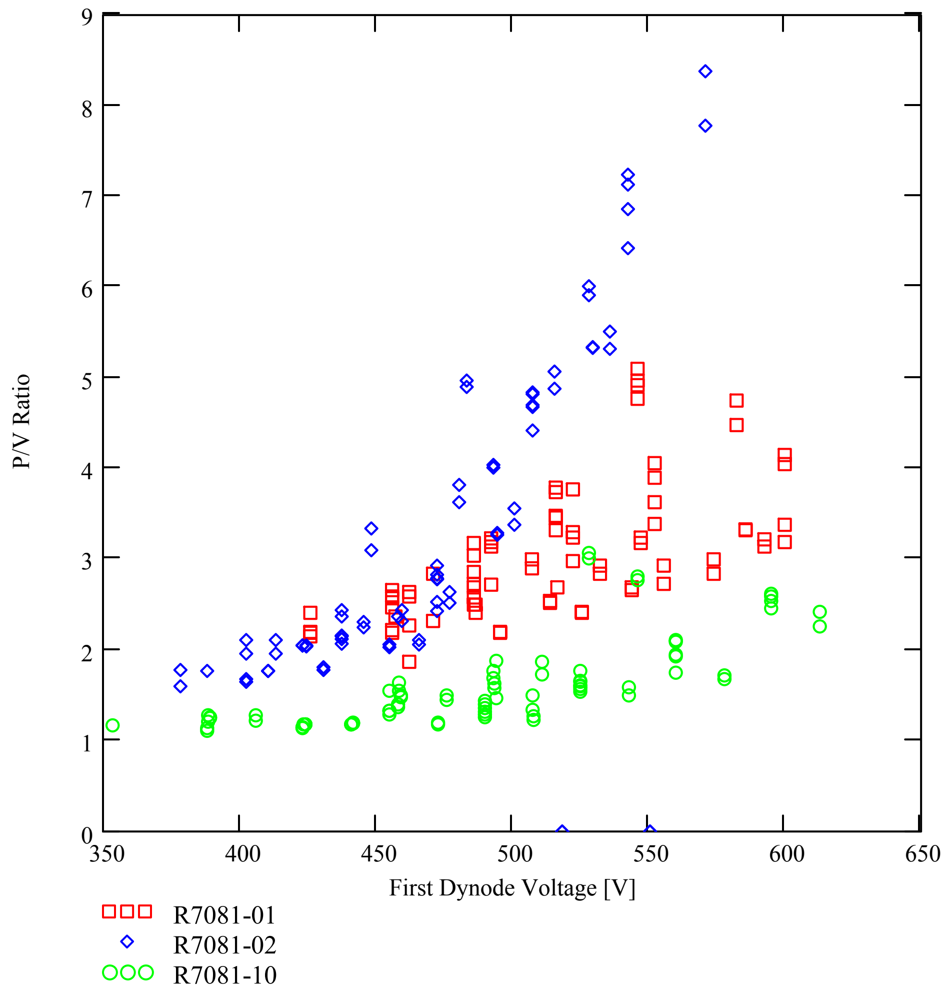


Figure 9

*PMT data by K. Hanson, B. Hughey, and A. Gassner, UW-Madison, Physics.