

First results on dark current measurements of the Hamamatsu's MAPMT R7600-03-M64

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In the EUSO experiment it is very important to choose a detector with a very low noise. The Hamamatsu MAPMT R7600 is certainly very quiet. However it is a general characteristic of all photomultipliers to show a big amount of noise immediately after a strong illumination. This could be very worrisome if the recovery time were too long, due to the fact that the useful data taking time during each orbit is of the order of 10 minutes.

We present here our preliminary measurements of the dark current behavior of a MAPMT tube. Specifically we measured the dark current after leaving the tube in darkness for many hours and its time dependence after a strong illumination.

The used setup is shown in Fig 1:

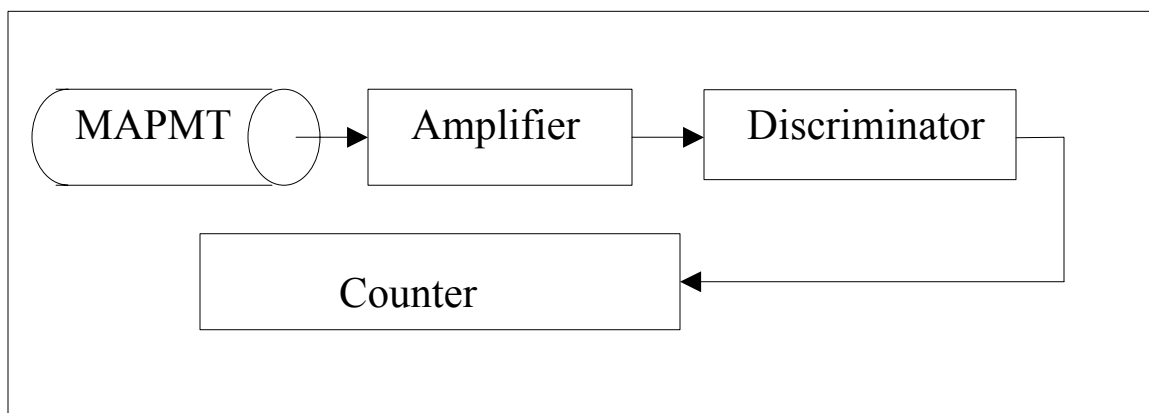


Figure 1

The expected output signal from a single photon can be roughly evaluated using the nominal gain and assuming that the pulse shape is approximately triangular with a base width of 6 ns (as shown in the manufacturer's datasheet) on a load resistance of 50 Ω :

$$V_{peak} = 2 q G R / \Delta t$$

where q is the electronic charge ($1.6 \cdot 10^{-19}$ C), G is the MAPMT nominal gain, R is the load resistance (50Ω) and Δt is the pulse width (about 6 ns).
We obtain the following table:

Voltage (V)	800	850	900
Gain	$3 \cdot 10^5$	$6 \cdot 10^5$	$1 \cdot 10^6$
Pulse Amplitude (mV)	1.5	3.0	5.0

Table 1

The expected signal is too small to be fed directly into a discriminator, so we first amplify it with a wide band (≈ 100 MHz) amplifier having a gain of ≈ 100 .
The dark current rate measured on a single pixel of a tube left in the dark for many hours is shown in table 2 for various threshold settings:

Voltage (V)	850	850	850	900	900	900	950	950	950
Threshold (mV)	60	70	80	60	70	80	60	70	80
Count rate (Hz)	4.2	2.6	2.3	3.5	3.5	2.3	6.8	4.9	3.9

Table 2

The dark current level changes considerably after an extended exposure to daylight. To quantify this effect we exposed the tube to room light (mainly neon light) for about 150 s, then we quickly closed the box and started to measure the dark current rate during the following 10 minutes.

Typical result are shown in figures 2 and 3:

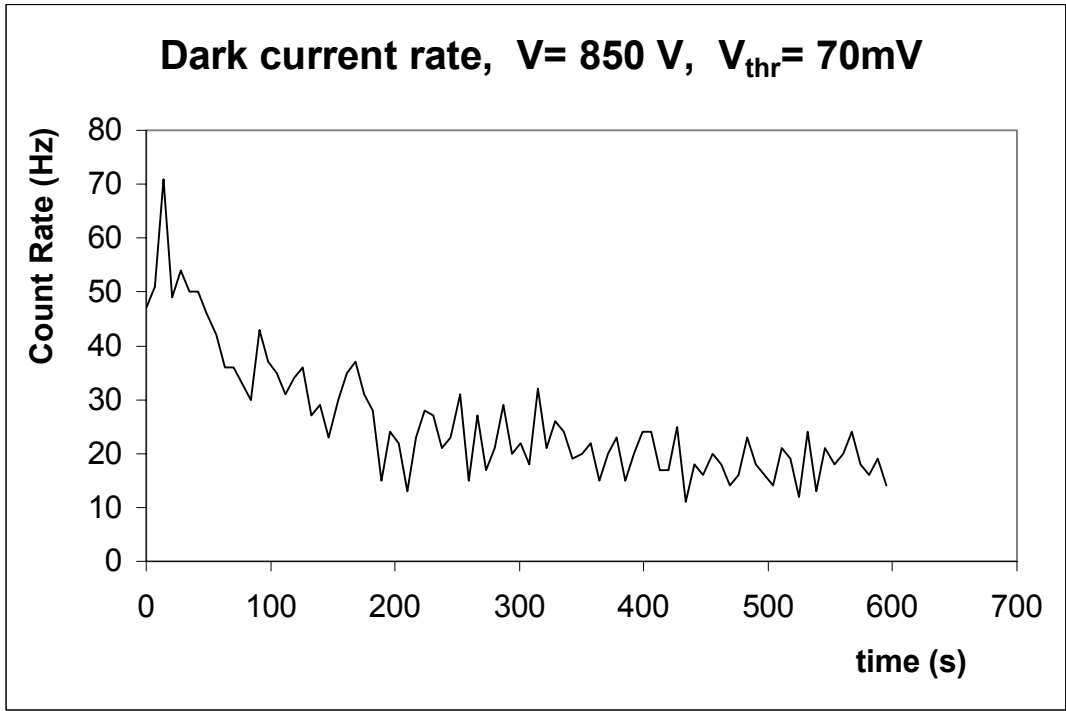


Figure 2

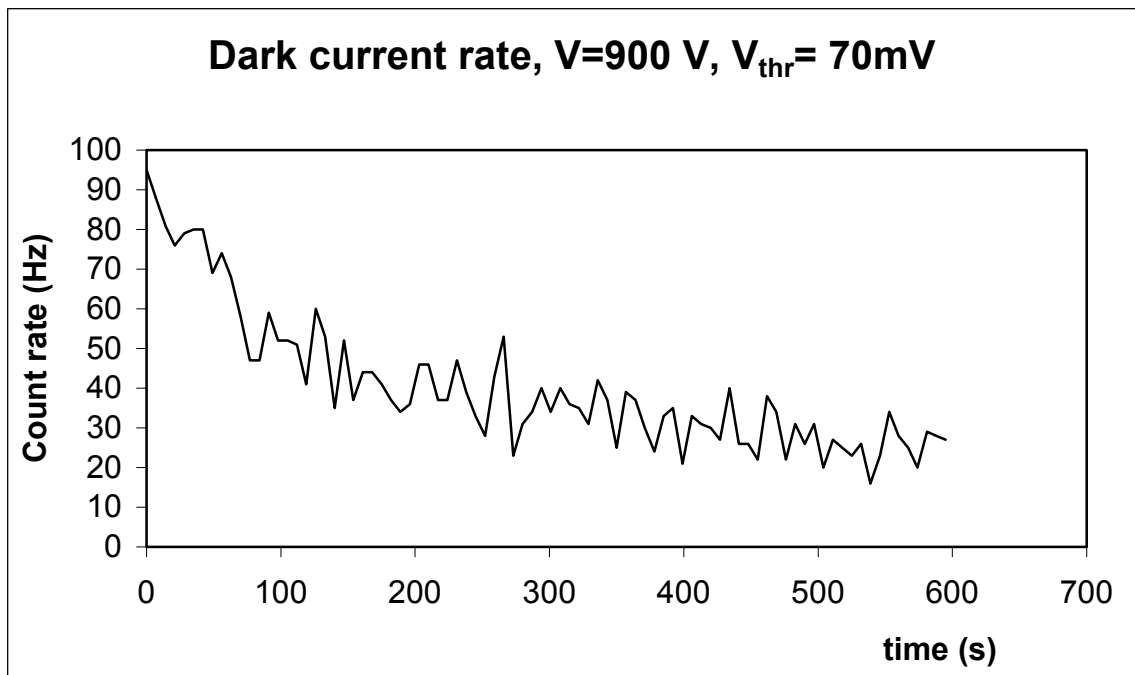


Figure 3

A summary of results obtained under various conditions is shown in table 3:

Voltage (V)	850	850	850	900	900	900	950
Threshold (mV)	60	70	80	60	70	80	60
Count rate after illumination (Hz)	50	55	50	95	90	95	250
Count rate after 10 minutes (Hz)	12	18	12	30	27	15	30
Decay time constant (s)	96	88	90	94	68	70	See text

Table 3

The case of $V=950$ V is apparently different from the others: a fit with a single exponential is not satisfactory. An acceptable result can be obtained only by fitting with a sum of two exponentials; in this case the two time constants result to be 29 s and 630 s. More work will be required to understand the reason of this effect.

To better understand the time constants involved in the problem we also tried to collect data for a longer time interval. We chose 850 V for the power supply and 70 mV for the threshold as a representative average working condition. The raw data are shown in figure 2, while in figure 3 the same data are shown again after some smoothing (obtained with a running average on 5 points).

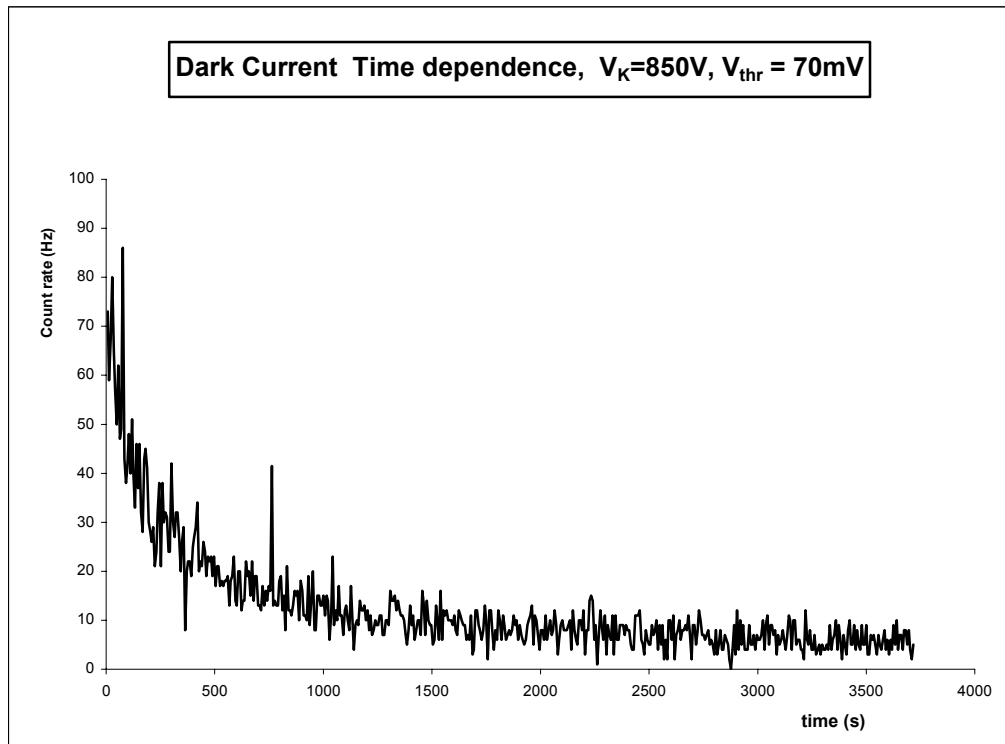


Figure 4

V_

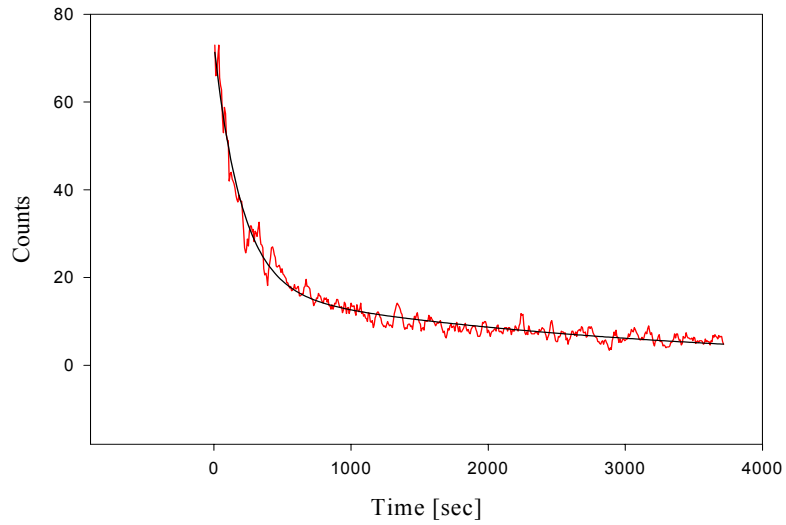


Figure 5

The super-imposed fit in figure 5 is the sum of two exponentials:

$$Rate = A \exp(-t / \tau_1) + B \exp(-t / \tau_2)$$

The four constants are: $A = (56.1 \pm 0.7)$ Hz, $\tau_1 = (200 \pm 4)$ s, $B = (17.3 \pm 0.4)$ Hz and $\tau_2 = (3300 \pm 1000)$ s.

After one hour the count rate lowers to ≈ 5 Hz, rather low but still higher than that measured after a longer period in darkness.

Conclusions

We have shown that after strong illumination, such as it might happen when the pixel is hit by light coming from a big city, one has to expect a rather steep increase of the dark current, reaching almost 100 Hz a few tens of seconds after the light flood. However this count rate should be compared with the one expected from the nightglow background and with that generated by stray lights, towns and other human activities at the Earth surface. The background light expected (Ref. 2) is ≈ 1 photon/(pixel μ s) and clearly this is much more worrisome than the intrinsic noise of the MAPMT. This increase of noise is, possibly, visible for a few seconds only after a strong light flood.

References

- 1) Data sheet of Hamamatsu's MAPMTs can be found in the web site:
www.hamamatsu.com
- 2) "BABY" Experiment: "Nocturnal atmospheric UV background measurements in the 300-400 nm wavelengths band with BABY 2001, a transmediterranean balloon borne experiment", S. Giarrusso et al.
Proc. 27th ICRC, Copernicus Gesellschaft, Vol.HE, pp.684-686, 2001.