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Quality assessment tests of Hamamatsu M16 photomultipliers

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Abstract

The first group of delivered M16 photomultipliers (39 in total) were tested in the quality assessment test setup for the photon detector of the HERA-B experiment. The sample tuned out to be homogeneous and confirmed the results of our previous tests.

1 Motivation

The RICH photon detector of the HERA-B experiment at DESY, Hamburg, will be build of 1500 16-channels multianode PMTs and 1000 4-channels PMTs. The quality assessment test is therefore needed to check their quality and to provide the relevant PMTs characteristic data. The optimal value of high voltage as well as plateau count rate of all the PMT channels should be provided for further analysis. This data are important for an appropriate assignment of tubes to groups with equal high voltage.

While designing the setup for testing, we should bear in mind the stability of the photon source, the easy exchangability of the PMTs, a relative easy data analysis and a small time consumption for a single test. The setup has been constructed and is described in the following section.

2 The multianode PMT quality assessment set-up

Four M16 PMTs are mounted in a PMTs base board (painted black) with the PMT socket, base resistor chain and ASD8 board connections (Fig. 1). The board is fastened by screws to the steel plate. The plate is covered at the PMT side by a cylindrical aluminium box. To prevent light leaks into the test volume, the steel plate is attached to the cylindrical Al box via channels (see Fig.2) which allows an easy exchange of the PMTs. On one side of the 100 mm long aluminium box (painted black) a 1 cm thick LiF window is incorporated and used as Čerenkov radiator medium. The exit window of the LiF crystal is 80 mm from the PMTs cathode layer. A strong (1 mCi) Sr beta source provides electrons which, in turn, radiates Čerenkov light in the LiF window.

While the PMT socket is on the inner side of the testing volume, the resistor chain and the contact pins to the ASD8 board are on the other side [2]. The bleeder resistor chain values are 1M:1M:1M:680k:680k:...:680k.

The serial numbers of the readout boards are 96081093, 96081111, 96060970 and 96081095. The analog output (the amplified channel 15) are enabled on all the boards used, so that it is always possible to control one of PMT channels on the scope.

Negative digital outputs of the ASD8 are fed into an ASD8 to ECL converter (using LeCroy MVL comparator) in the same way as in the previous M16 and M4 tests [2]. The ECL outputs are connected to the scalers (CAEN 16 ch. scaler).

The HV for the PMTs is supplied by the CAEN programmable high voltage controller while the ASD8 threshold is controlled by a DAC CAEN CAMAC unit. The data are collected by a LabWindows data acquisition program which runs on the Windows 95 platform. The same program controls the applied high voltage and the ASD8 threshold level. The PC is connected to the HV Controller through a PC CAENET card and to the CAMAC via a GPIB interface. The gate for the scalers is given by the CAMAC gate generator unit.

The output, ASCII files with 18 variables (the HV value/ threshold value, time of measurement and the count rates of 16 PMT channels) for each photomultiplier, is analysed in PAW.

3 Expected illumination

Since the illumination of the tubes in the set-up is slightly inhomogeneous, we determined the expected distribution of photons on the cathode layer of the PMTs using a MC simulation program [1]. In the simulation Sr electrons are generated. They are propagated to the LiF crystal, where ionisation losses are calculated for small enough steps. The Čerenkov photons are emmited and propagated to the output window of the LiF and further on to the cathode layer of the PMTs. Multiple scattering of electrons in the LiF is taken into account as well as total photon reflection and absorption in the crystal. The procedure is repeated until the electron energy is under the threshold for Cerenkov radiation.

The result of the simulation, the distribution of the hits on the PMT pads, turns out to be quite uniform with maximum variation of 8% from the average value (Fig. 4).

4 The testing procedure

To check the stability of the tests one of the four PMTs remained as a reference PMT in the setup for the whole time of measurement and will be kept there to the and of the Q.A. test.

The procedure is straightforward: First the three PMTs are plugged into the PMT sockets. The testing plate is then covered with the aluminium box and left for about 10 minutes. This time is, according to our experience with tested M16s, considered to be sufficient for reducing the noise, since the background rate always drops to a few Hz at 700 V after some minutes in the darkness, and the measured rate is around 30 kHz.

The high voltage curve and threshold curve are then measured. After the test the high voltage is automatically set to zero and the threshold for ASD8 to -2 V. The procedure is repeated with the next three PMTs.

5 Results

In total, a set of 38 PMTs was tested. They are all quite homogeneous. For each of them two curves were measured. The rates from all 16 channels were measured for different high voltages and different thresholds were recorded. The raw data are kept in ASCII files and are made accessible to anyone via ftp://merlot.ijs.si/r̃ok/m16test/xxxxxx.yz where xxxxxx is the serial number of the tested PMT, y position of the pmt in the test setup (1,2,3), while z is 0 for threshold scan and 1 for high voltage scan.

To account for the slight inhomogeneity of the illumination of chamber as discussed in section 2, we have corrected the measured rates by using the distribution of photons as determined from the simulation (Fig. 4). The correction factor ranged from 0.9 to 1.1 for the pads closest and furthest from the source.

6 Conclusions

To summarise, we note that:

- the Q.A. set-up performed well
- the performance of the tubes was in agreement with required specs

A database is being set up that will include all we have learned about each tube, and will be further used for assigning to each tube the proper position on the photon detector.

References

[1] P. Križan et al., Test of a Multianode PMT for the HERA-B RICH, to be published in NIMA.

[2] P. Križan et al., ASD8 Chip Tests with a Hamamatsu Multi Anode Photomultiplier, IJS DP-7615.

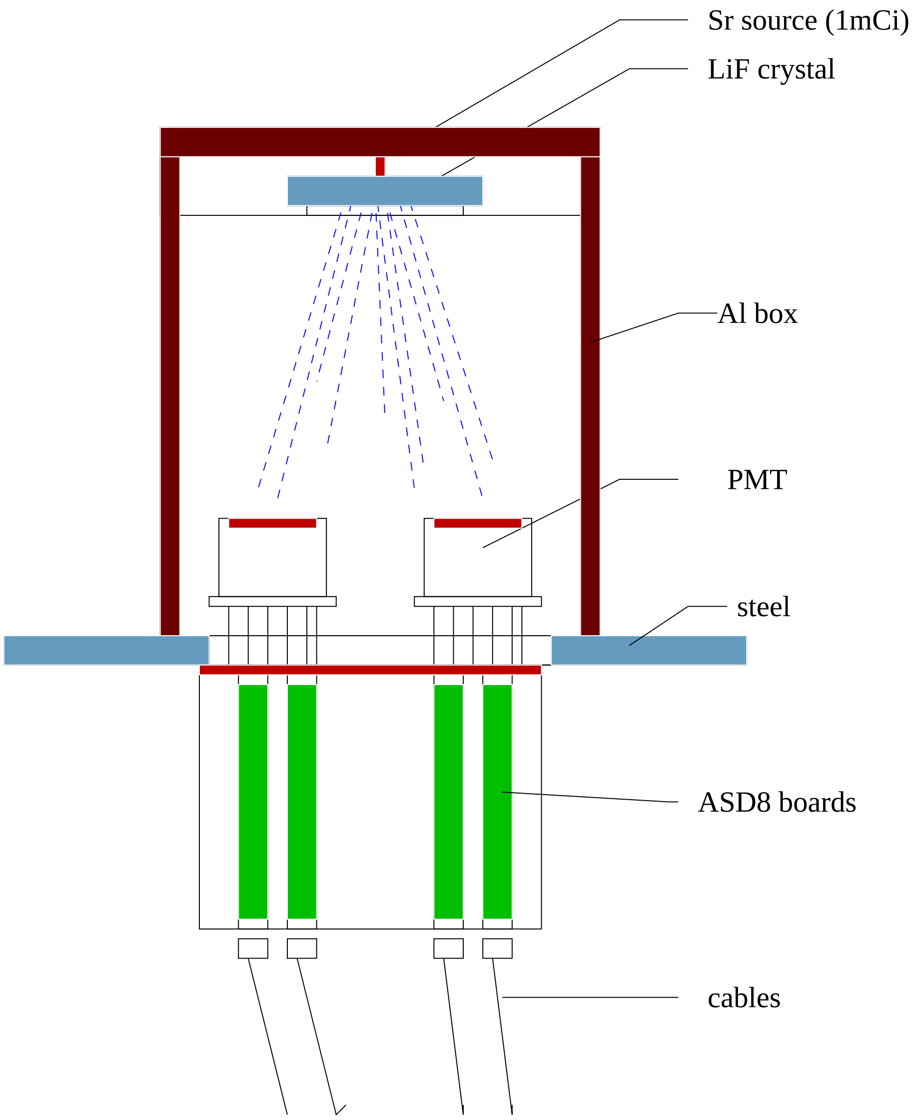

Figure 1: *The experimental setup.*

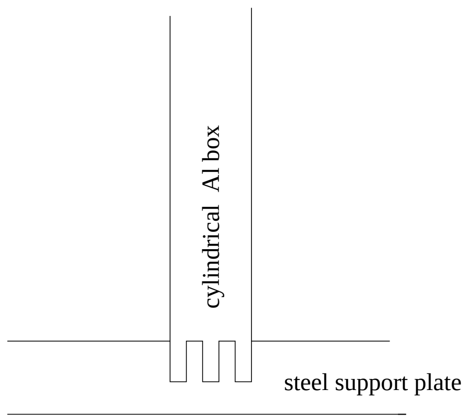

Figure 2: *The connection between the metal plate and the aluminium box.*

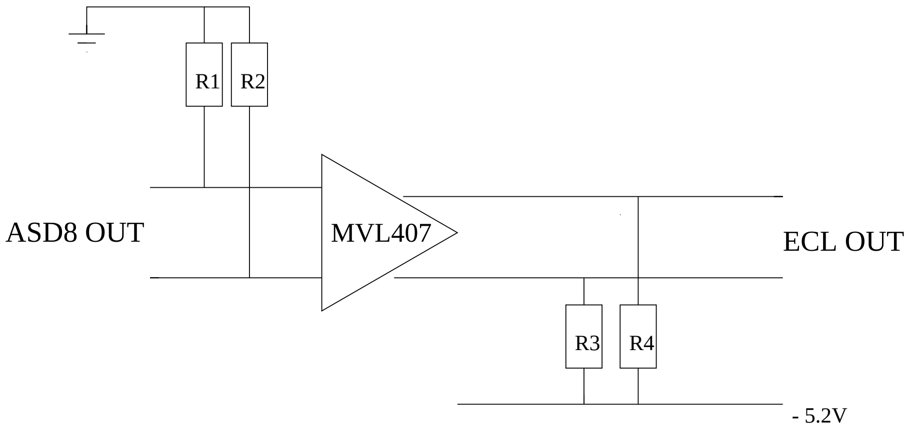

Figure 3: *ASD8 logical output to ECL converter (R1=R2=50Ω,R3=R4=500Ω, MVL407= LeCroy MVL407).*

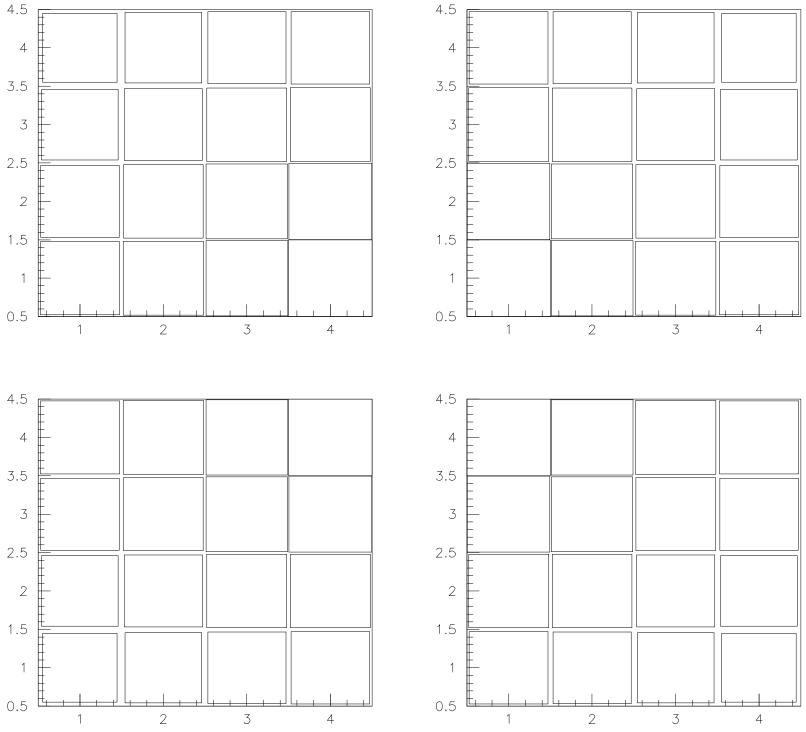

Figure 4: *The expected distribution of photons on the cathode layer of the PMTs.*

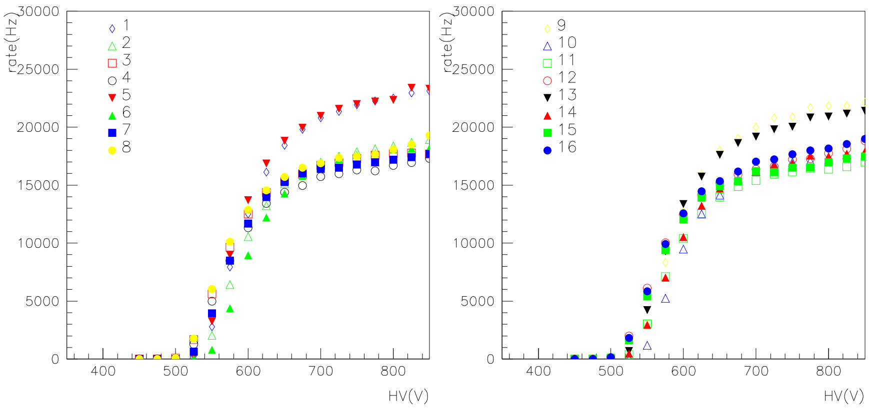

Figure 5: *High voltage scan for the reference PMT.*

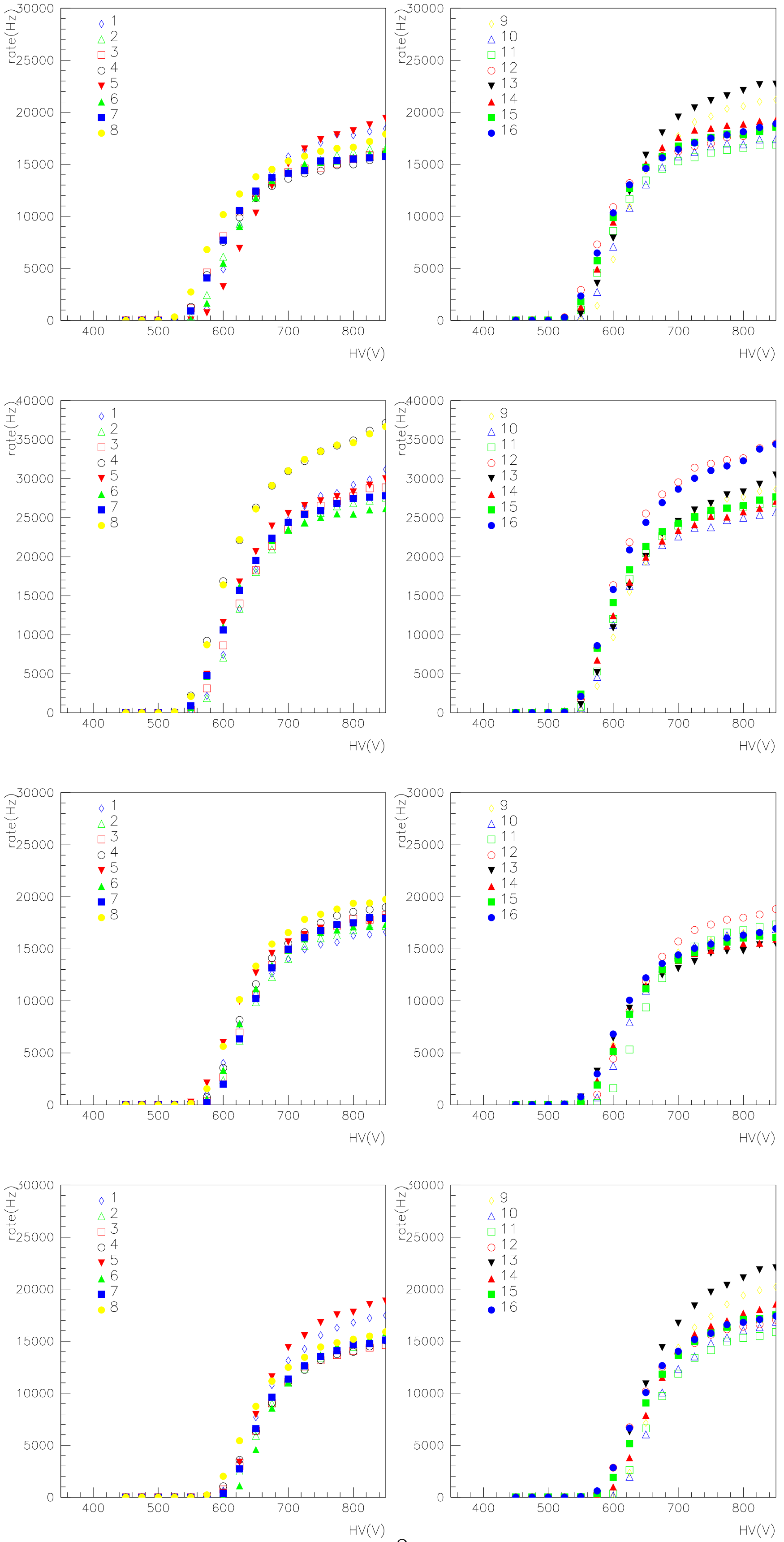

Figure 6: *High voltage scans for the PMT M16 serial number 6e07c3, 6d15c2, 6l01r2 and 6l05r3.*

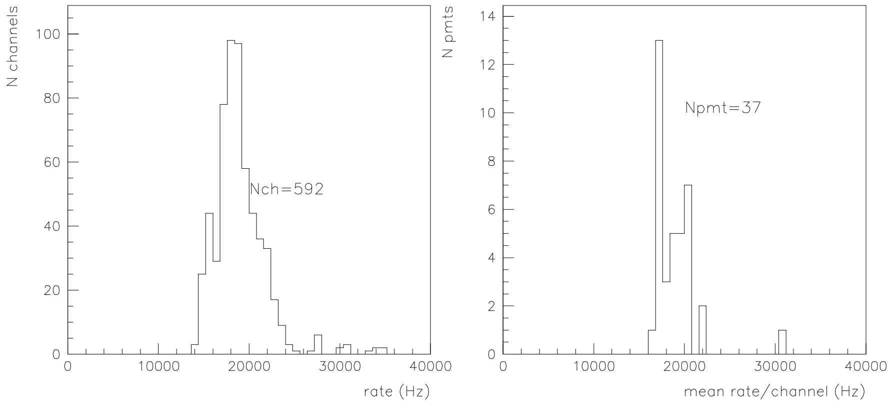

Figure 7: *Distribution of counts for all the channels (left) and for the PMTs (right) at 750 V, ASD8 threshold was set to -1.2 V .*

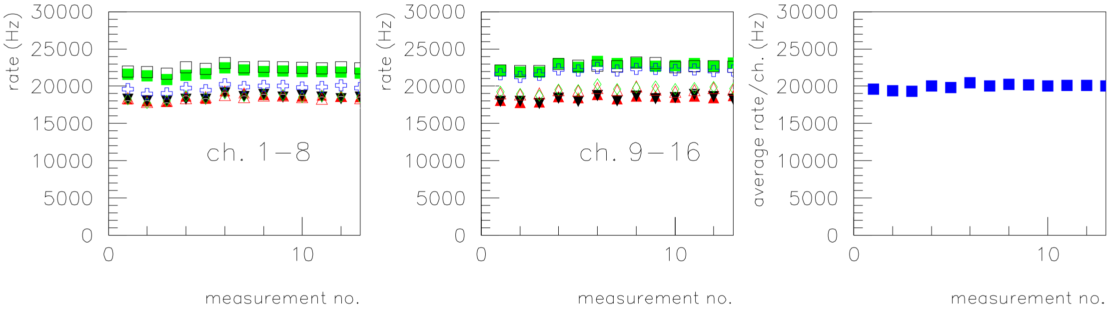

Figure 8: *Reference PMT stability: rate for all the channels (left,middle) and mean rate per channel for the whole PMT (right) as function of test number. High voltage was set to 750 V, ASD8 threshold was at -1.2 V.*

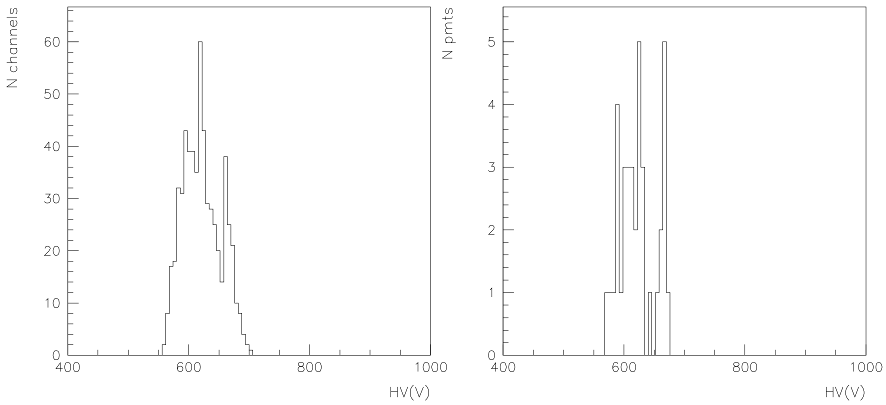

Figure 9: *Gain uniformity: Distribution of voltages at which half the value of the rate at 825 V is reached: for separate channels (left) and for the average over PMT (right).*

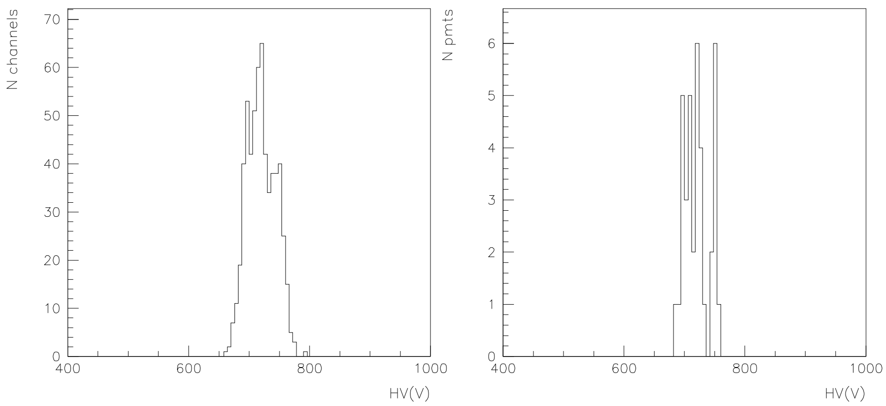

Figure 10: *Gain uniformity: Distribution of voltages at which 90% of the rate value at 825 V is reached: for separate channels (left) and for the average over PMT (right).*