Effect of 100% He on H5191X/H2431 Photomultiplier Tubes

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Abstract

Three photomultiplier tubes, one of fine-mesh type and the other two of conventional type, were placed inside a gas-tight sealed container with 100% helium for about 20 days. After pulses appear and can be seen on the oscilloscope after some time. They occur at about 250 ns after the main pulse for the conventional tube and at 100 ns for the fine-mesh tube. It was observed that the mean ADC distribution tube and 100 ns for the fine-mesh tube. It was observed that the mean ADC distribution of the afterpulses increases as the time of exposure to helium is prolonged. It was also found out that the rate of increase of the afterpulse is the same for the fine-mesh tube and the conventional tube.

Experimental Set-Up

A fine-mesh type phototube (H5191X) with 9.0 cm thick plastic scintillator attached and two conventional phototues (H2431) each with 1.0 cm thick plastic scintillator were placed in a gas-tight 60x-40x10 cm^3 sealed box containing pure helium. Two tubes were inside this pure helium environment for a total time of about 470 hours while one tube (H2431, old) was exposed for 115 hours less. This old tube was previously exposed to 10% He concentration continuously for 25 days and had already noticeable afterpulses of about 60 mV pulse height before it was immersed in pure helium.

The empty space of the box was filled with 12 blocks of iron measuring 20x10x5 cm^3. This also reduces the purging time when the box is opened for measurements. After measurements, helium gas was flown at 200 cc/min

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for the first 3 hours and 100 cc/min subsequently.

High Voltage

High voltage was not applied when the tubes were exposed to helium and no radioactive source was present. The high voltage on the tubes was applied only when measurements were taken. It was found out that all tubes do not hold high voltage after <20 hours of continuous exposure in a sealed environment of 100% helium. It is necessary to take the tubes out of the sealed box, wait for rate of helium diffusion could indicate that helium gas saturates the space of the base of the tubes and renders it inoperable at high voltage.

The tubes were subjected to the following HV at measurement time:

* A. H5191X, @1610 V, dark current = 0.077 mA
* B. H2431 new, @2320 V, dark current = 0.405 mA
* C. H2431 old, @2520 V, dark current = 0.445 mA

There was no change in the dark current during the whole exposure time. The readioactive source used was Sr. 90. During the measurements, the HV was left on for at least 30 min to avoid hysteric effect [Yamashita, 1978] wherein the gain is anomalously changed when the source is suddenly introduced. Only after this time were the ADC/TDC data taken.

Electronics and Data Acquisition

Measurements were made on each of the three tubes during 24-hours intervals or more. First, the pulse height of the main pulse and afterpulse were observed directly on the oscilloscope and very low settings were used to look for the afterpulse.

As for the ADC data, the gate was opened 100 ns after the main pulse for a gate width of 500 ns to look for the afterpulse. The ADC distribution of the main pulse was also taken with the same gate width.

Two outputs from the discriminator were connected to the TDC to scan the time interval after the receipt of the main pulse. The START input was delayed by 200 ns to scan the time interval from 200 ns - 400 ns after the receipt of the main pulse.

The electronics for the data acquisition is given in figure 1.

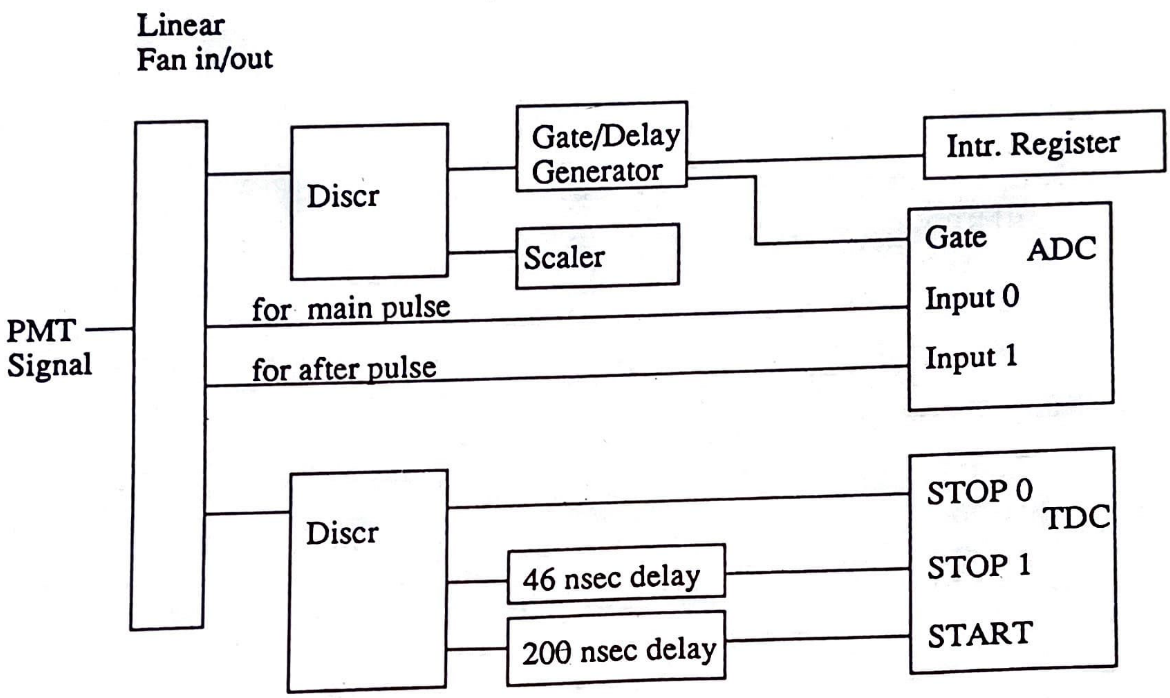


Figure 1. Electronics for the data acquisition used in the expiriment.

Results of Measurements

The oscilloscope picture for the pulse heights from the tubes are shown in the Figures for different exposure times. The afterpulse for the fine-mesh tube occur at around 100 ns after the main pulse and for a magnitude of about 30 mV after 470 hours of helium exposure. The afterpulses for the conventional tube appear at about 250 ns after the main pulse. A second afterpulse also occurs for the conventional tubes.

ADC Distribution

The plots show the ADC distribution of the main pulse and afterpulse during different exposure time for the three tubes. The distribution for all tubes increases with time. The plot of the Mean ADC of Afterpulse vs Number of Hours (100% He exposure) summarizes and compares this variation for the fine-mesh and conventional tubes. The plot of the Relative Afterpulse (%) vs Number of Hours (100% He Exposure) is taken when the mean ADC at 0.0 hrs (before exposure) is taken as the reference afterpulse. It is seen that both the fine-mesh type and conventional type have comparable behaviors with respect to after pulse variation due to pure helium exposure. The mean ADC of the main pulse, however, shows no appreciable variation with time for both fine-mesh and conventional tubes as shown in the plot.

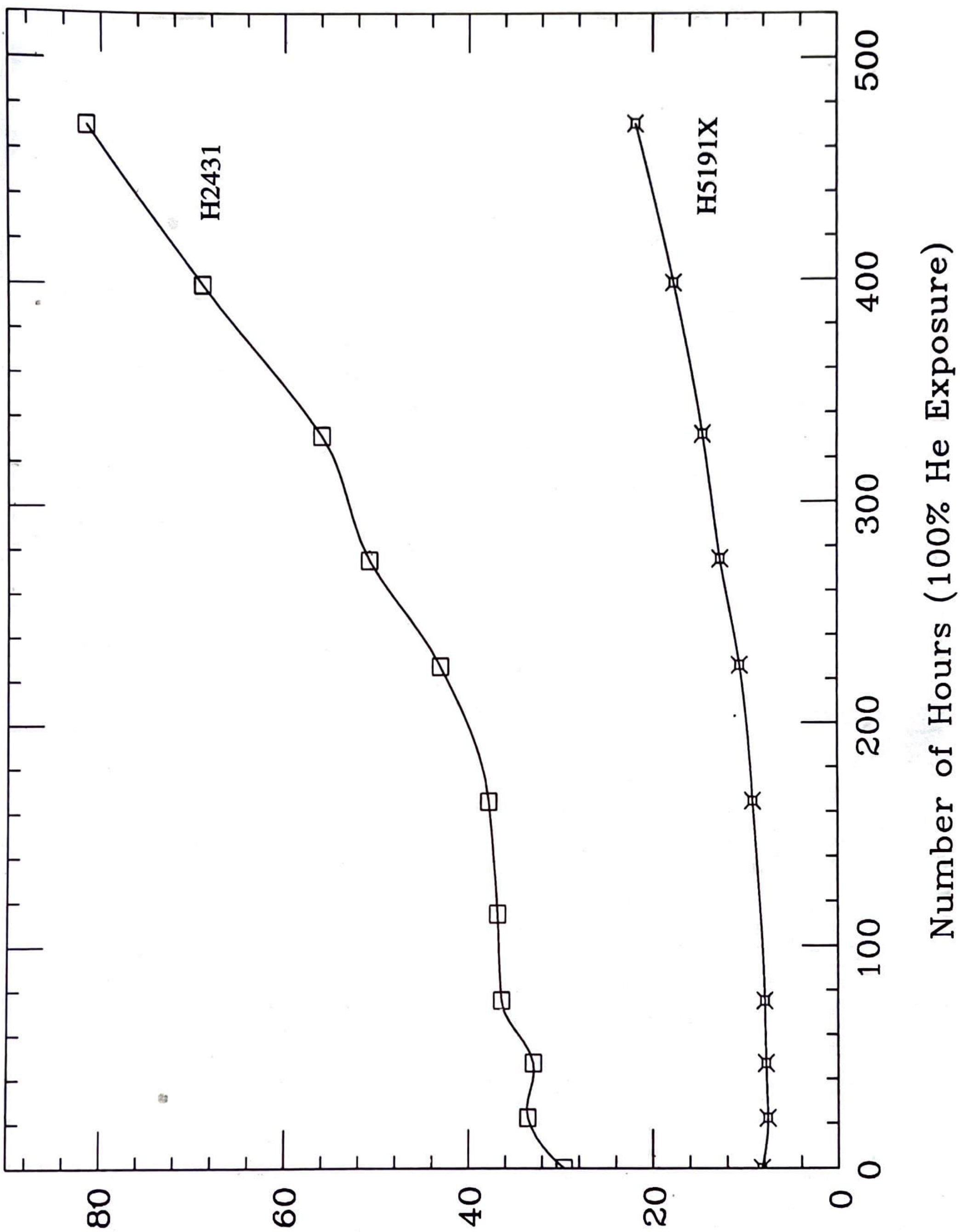


Figure 2. Mean ADC of afterpulse

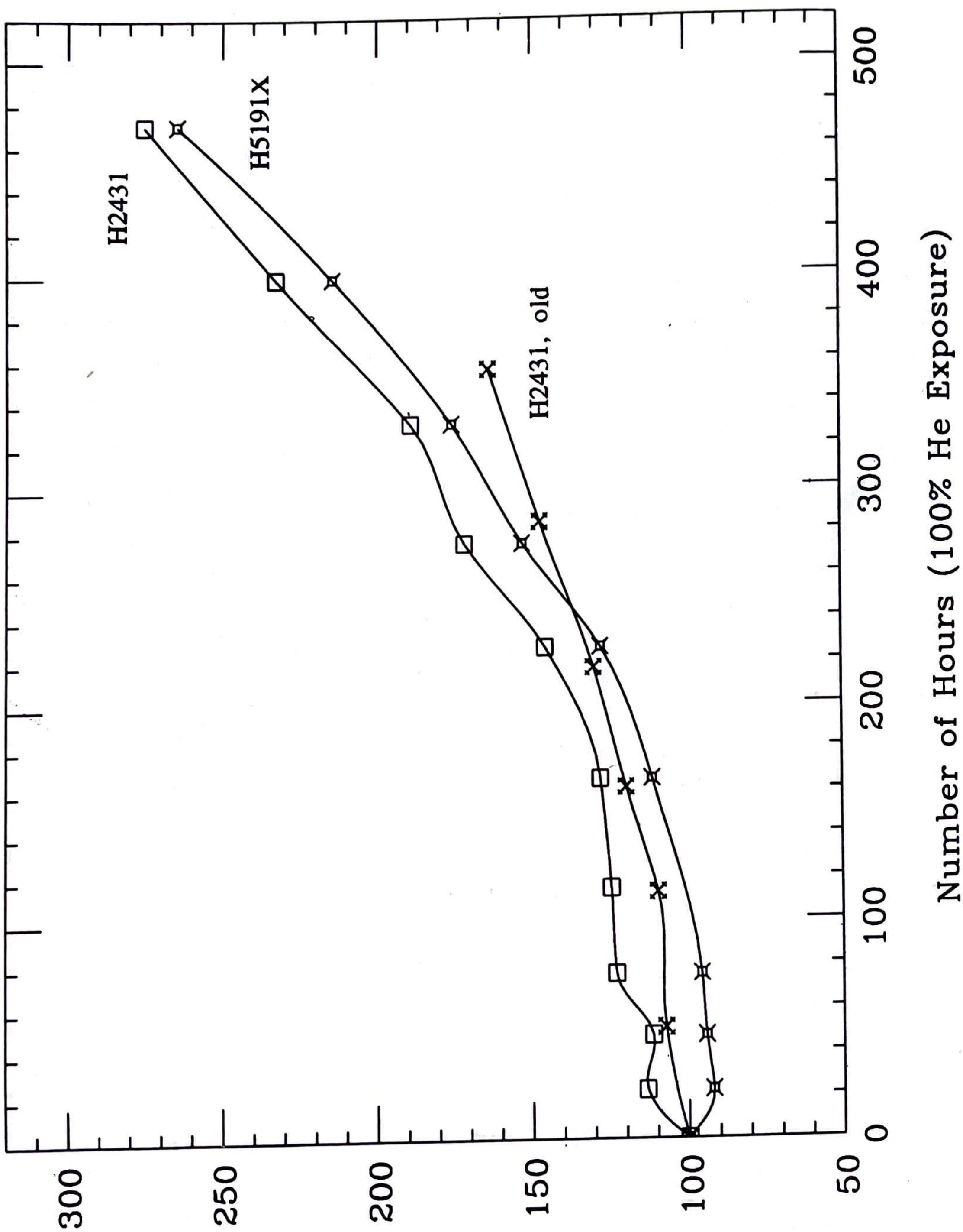


Figure 3. Relative Afterpulse (%)

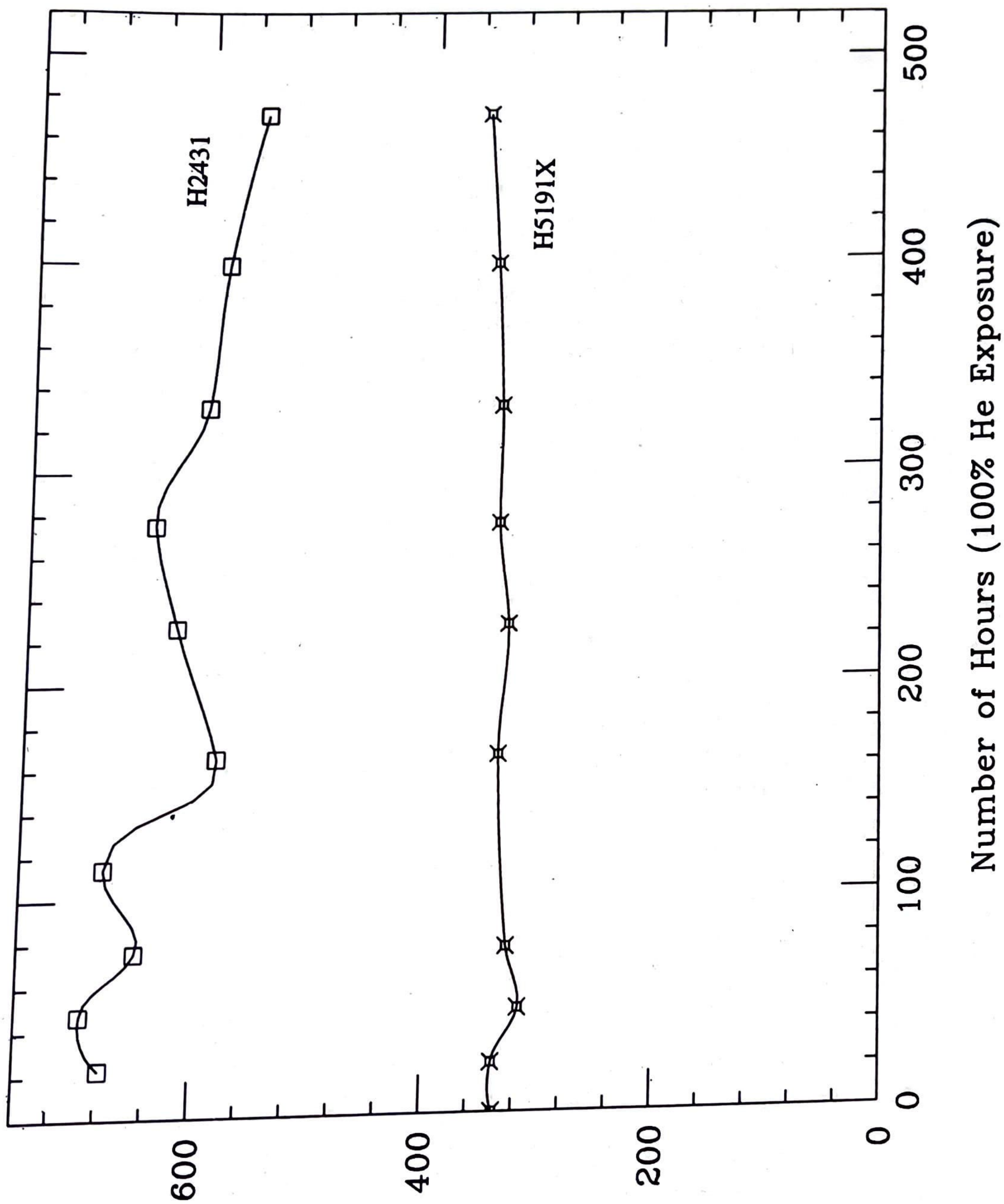
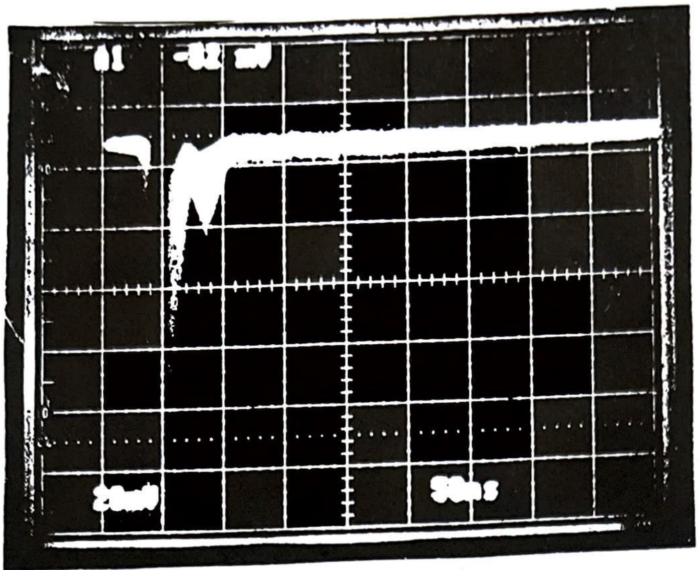


Figure 4. Mean ADC of Main Pulse



Vert. scale: 20 mV/cm
Hor. scale: 50 ns/cm

Figure 5. Fine-mesh type phototude (H519IX) before exposure to pure helium.

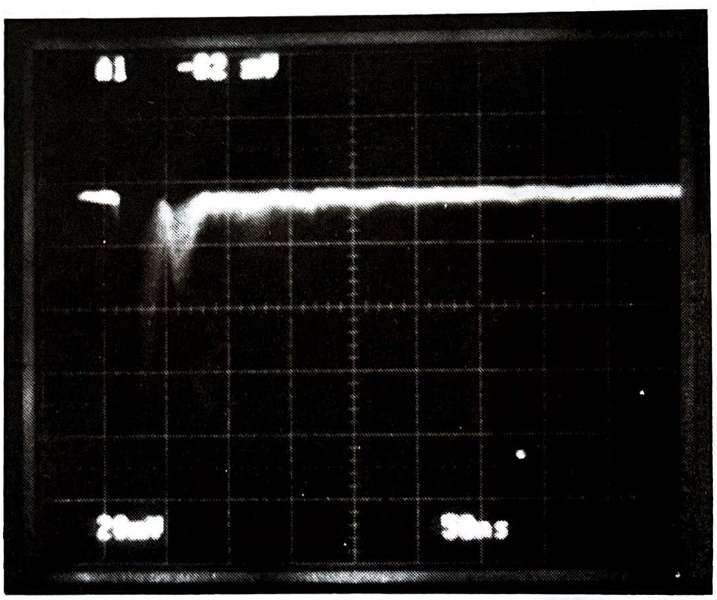
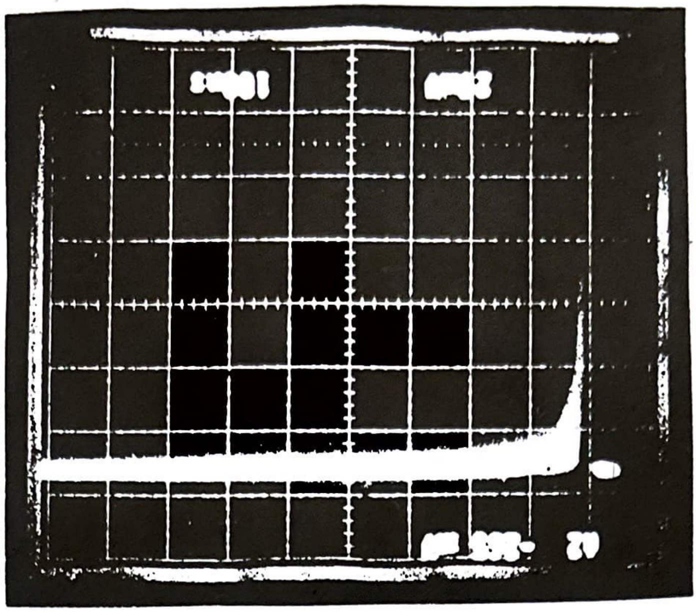


Figure 6. After 470 hours of pure helium exposure. Notice the afterpulse occurring 100 ns after the main pulse. (The scales are the same as the above figure.)



Vert. scale: 20 mV/cm
Hor. scale: 100ns/cm

Figure 7. Conventional-type tube (H2431) before exposure to helium.

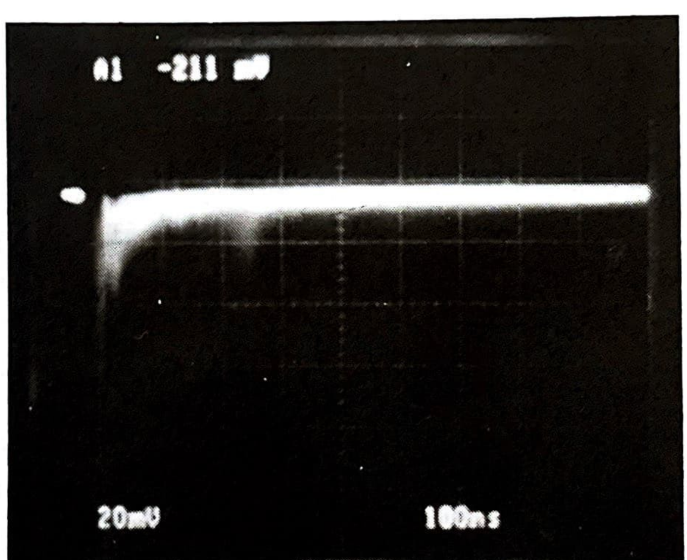
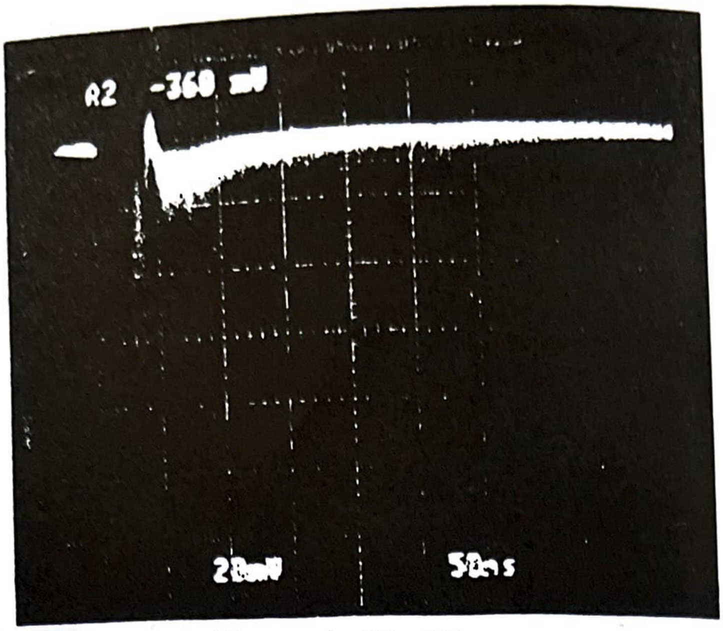


Figure 8. After 470 hours of helium exposure. The afterpulse can be seen about 250 ns after the main detector signal.



Vert. scale: 20 mV/cm
Hor. scale: 50 ns/cm

Figure 9. Old photomultiplier tube (OH2431) before pure helium exposure.

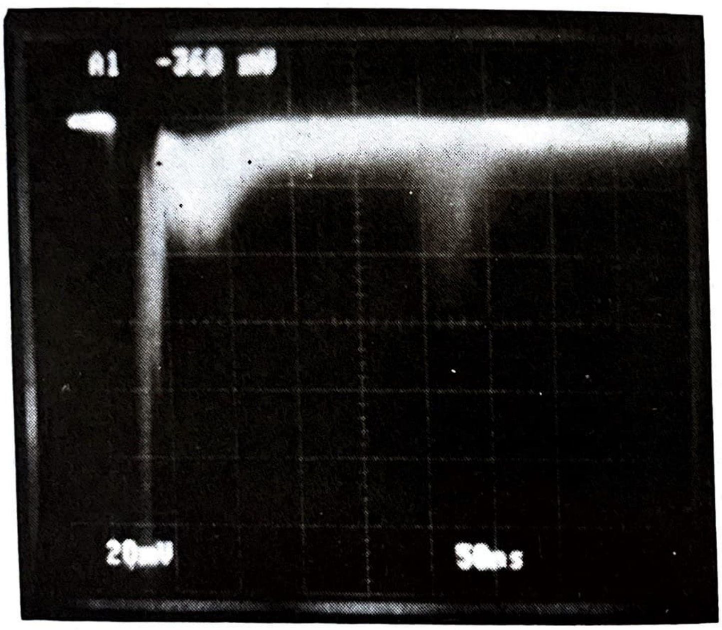


Figure 10. After 356 hours of 100% helium exposure. The afterpulse is remarkably present at a time of 250 ns after the main pulse.

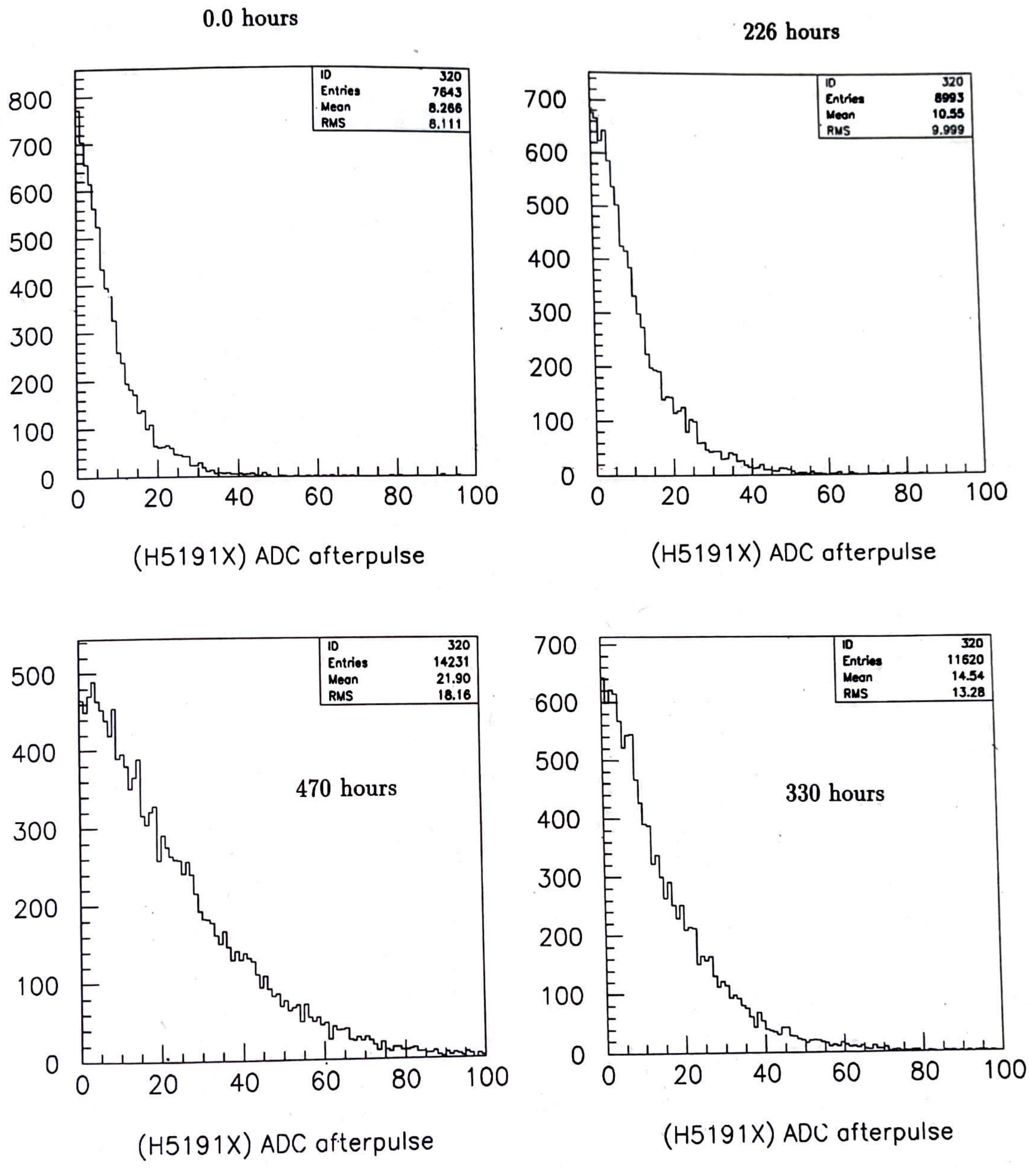


Figure 11. The ADC distribution for the fine-mesh tube type at different periods of pure helium exposure.

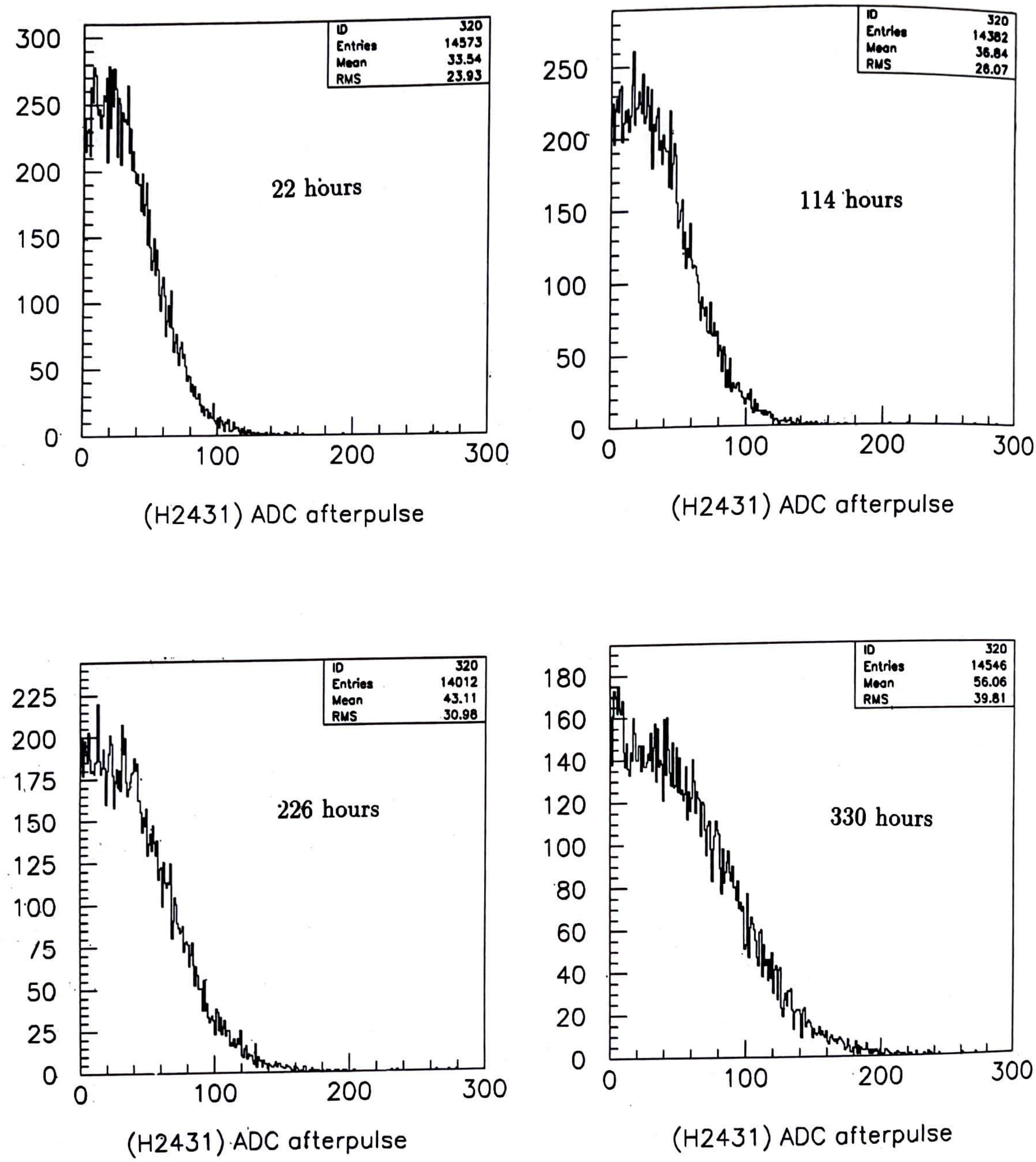


Figure 12. The ADC distribution for the conventional tube type at different periods of pure helium exposure.

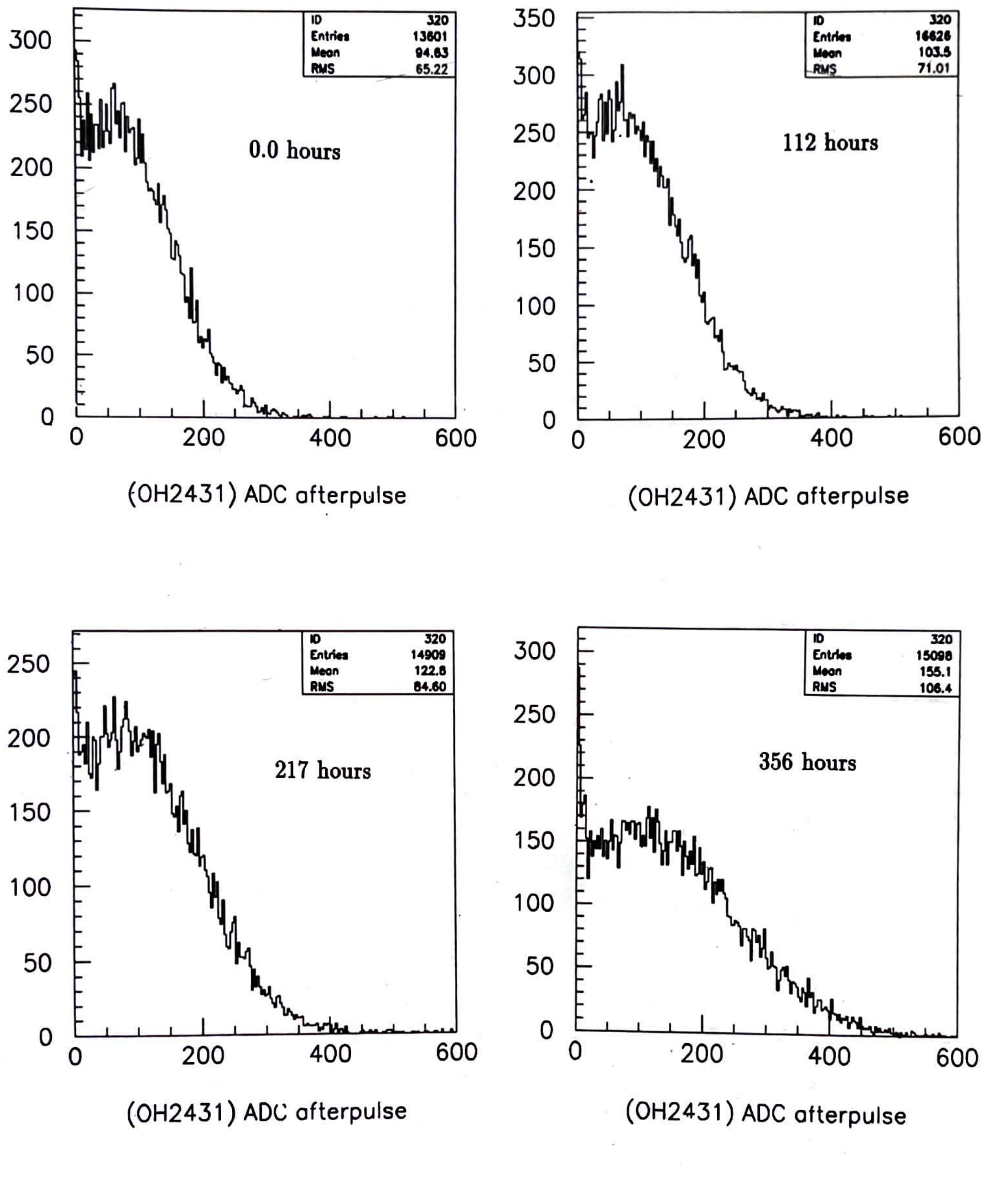


Figure 13. The ADC distribution for the conventional tube type (old) at different periods of pure helium exposure.