Pulse Shape from RMD APD with IR Laser

1 Experimental Conditions

The measurements were performed on a 8x8 APD with an Al grid deposited on the n-side and a continuous Al metallization on the p-side (sensor number 430-2-14). The sensor was mounted with the p-side facing down, see figure 1.

Conditions:

- Temperature: 20 C
- Bias and readout from n-side
- Amplification: Cividec C2HV amplifier with internal bias Tee (1 nF, 3 kΩ), 2 GHz / 40 dB nominal
- Infrared laser: 1060 nm, pulse duration $\approx$ 200 ps, intensity $\approx$ 12.5 MIPs
- Illumination from n-side, no reflections from p-side metallization
- Oscilloscope: 2.5 GHz, 20 GS/s

The schematic of the readout circuit is shown in figure 2, the attenuator was not used for these measurement. The cable length between the PCB with the sensor and the bias tee (1 MΩ, 4 pF) is 1.5 m, the connection between the bias tee box and the amplifier input is as short as possible.

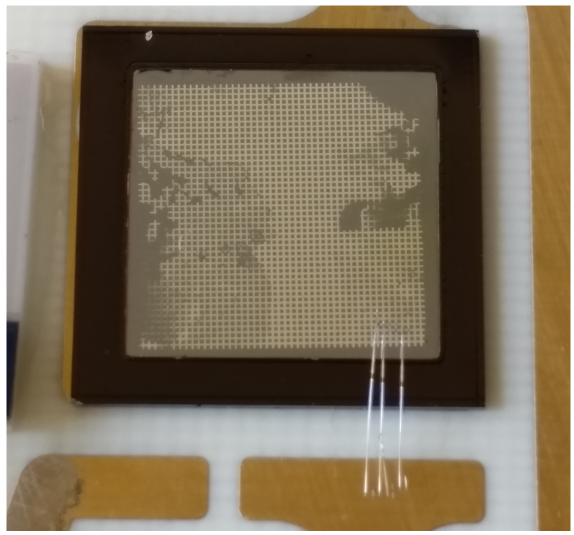

Figure 1: APD on CERN PCB.

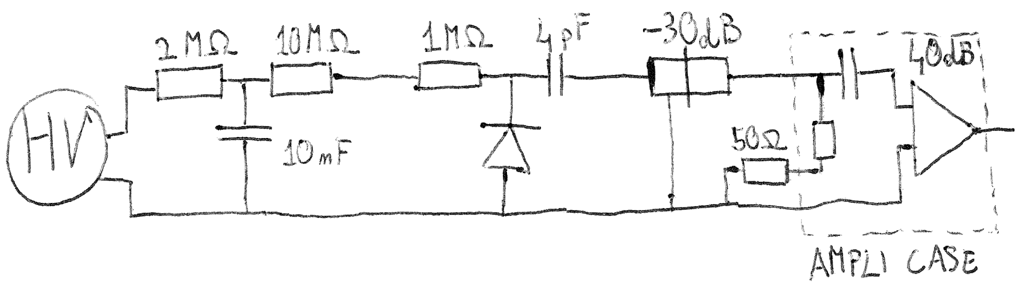

Figure 2: Schematic of the readout system, the attenuator was not used for these measurements.

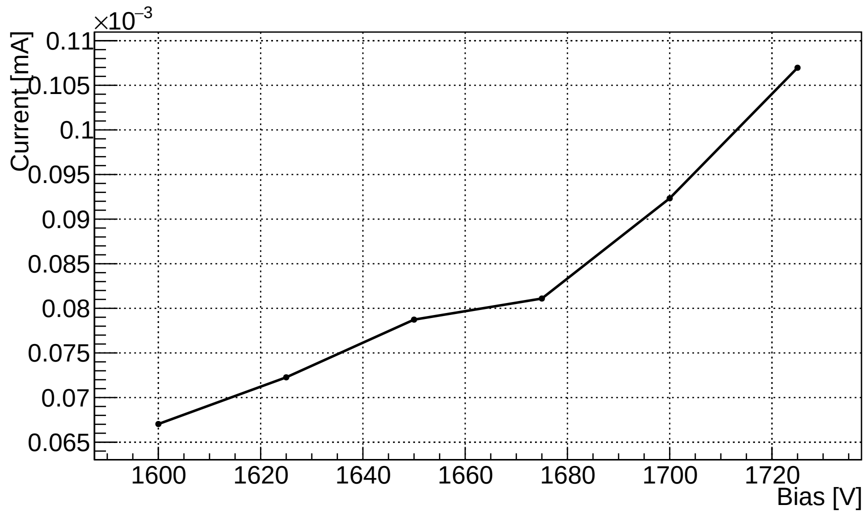

Figure 3: Current-voltage characteristic of the APD.

2 Pulse Parameters

The following figures represent the pulse and detector parameters as a function of bias voltage. The maximum bias voltage applied to the APD is dictated by the linear range of the amplifier that is ±1 V in output. For each voltage setting 1500 waveforms were acquired. The polarity of the pulse was negative when measured on the scope, here is reversed for clarity.

Figure 3 shows the current-voltage characteristic of the APD.

Figure 4 and 5 show the average pulse shape for each bias voltage.

In order to calculate the pulse properties, the baseline of the pulse is calculated for each waveform as the average voltage at times between 0 and 18 ns. The baseline is used to calculate the integral, amplitude, and noise of the pulse.

Figure 6 shows the average integral of the pulse as a function of bias voltage. The pulse is integrated for 20 ns for times between 18 and 38 ns. The integral is calculated with respect to the baseline.

Figure 7 shows the average amplitude of the pulse as a function of bias voltage. The amplitude is calculated with respect to the baseline.

Figure 8 shows the noise as a function of bias voltage. The noise is defined as the standard deviation of the distribution of voltages measured for times between 0 and 18 ns. These voltages are measured with respect to the baseline.

Figure 9 shows the signal to noise ratio defined using the amplitude of the pulse.

Figure 10 shows the 20% 80% rise time of the pulse as a function of bias voltage.

Lastly, since these measurements were performed to determine the timing of the detector, figure 11 shows the standard deviation of the Δt distribution as a function of bias voltage. The timing is determined using a CFD algorithm whose thresholds are optimized for each bias setting. The time reference used in the system has a resolution of $\approx$4 ps that could be subtracted in quadrature from the values shown.

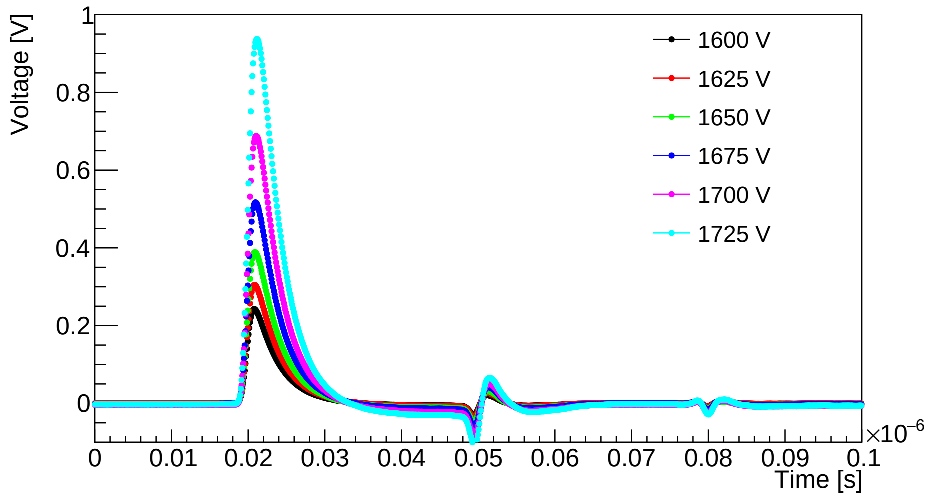

Figure 4: Pulses at different bias voltages. The reflection 30 ns after the pulse is due to a mismatch between the impedance of the cable and the one of the amplifier input.

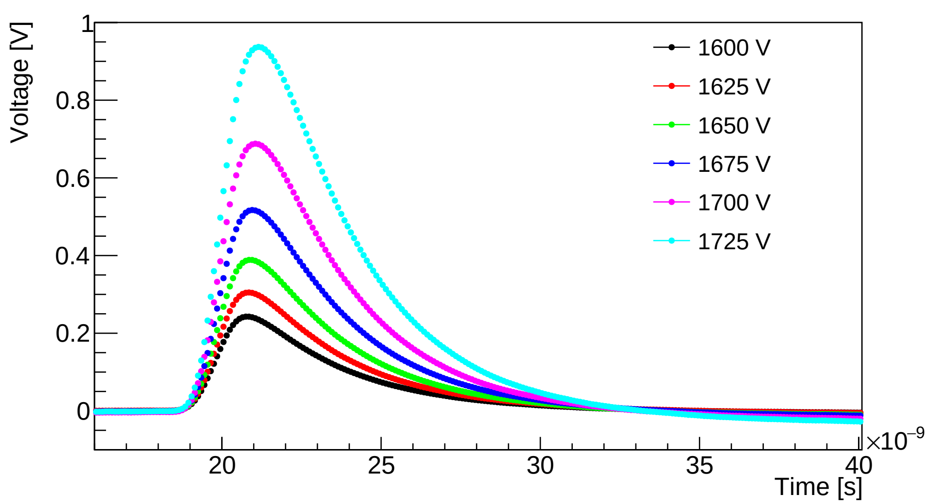

Figure 5: Same as figure 4, zoomed on x axis for detail.

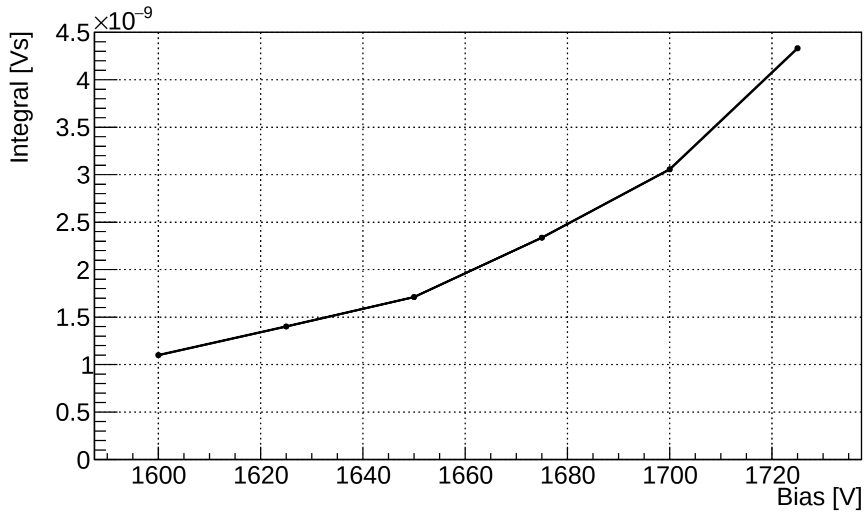

Figure 6: Integral of the pulse as a function of voltage.

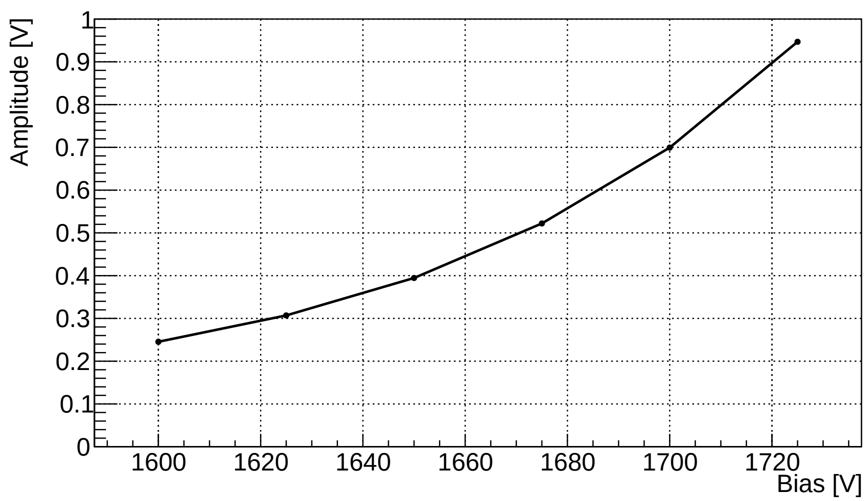

Figure 7: Pulse amplitude as a function of voltage.

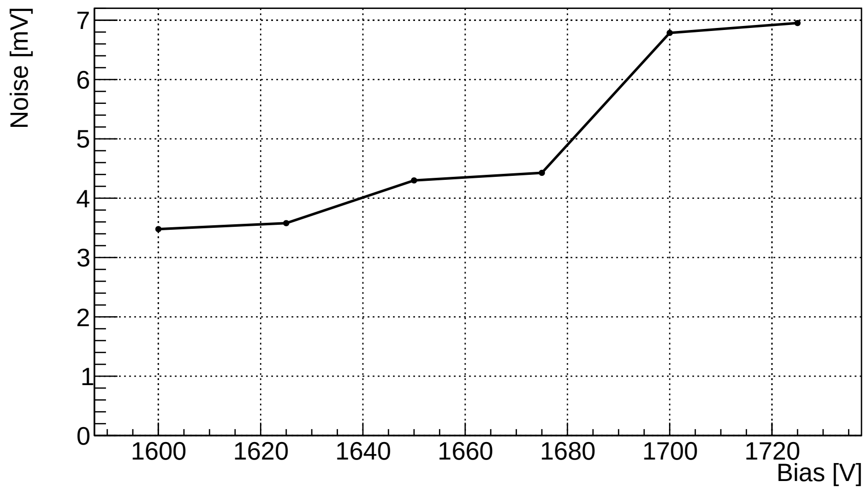

Figure 8: Noise as a function of voltage.

Figure 9: SNR as a function of voltage.

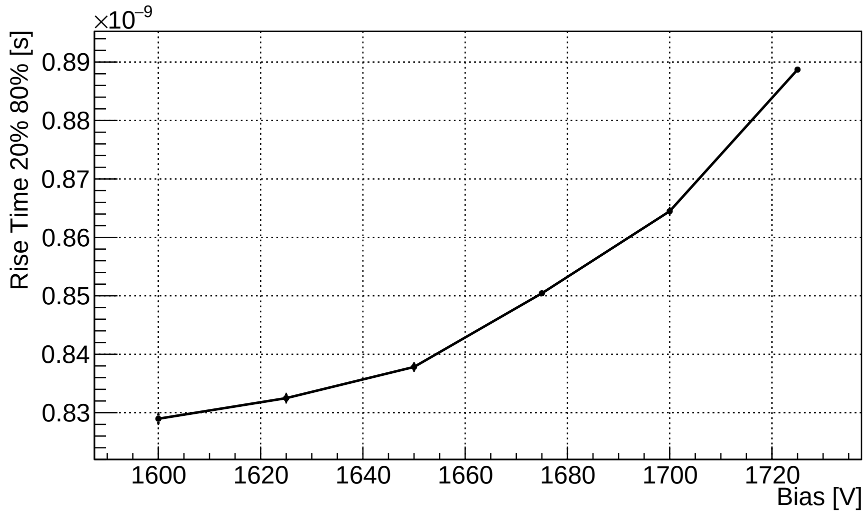

Figure 10: Rise time 20% 80% as a function of voltage.

Figure 11: Standard deviation of the Δt distribution obtained with a CFD algorithm optimized for each bias voltage.