Measure and Meaning

The single-photon measurements described in Chapter 2 are carried out in a quantum optics laboratory equipped with components arranged on an optical table, such as photonic sources, polarizing beam splitters, mirrors, phase shifters, and finally photodiodes or other devices to collect the photons at the edges of the set-up. How is

Figure 5.14: Single-photon detector, similar to that used in Hubble Space Telescope. Constructed by the Department of Physics and Astronomy, University College.

it known which, if any, of these components have induced a measurement event to occur? And which components instead operate in a unitary manner? Certain of these devices may have been designated as a *detector*, perhaps as seen on the label of a carton shipped from a manufacturer, or by a colleague in our laboratory who had designed the device, Figure 5.14. If the intensity of the source is sufficiently low, the detector is found to record pulses representing the arrival of a photon separated by intervals in time during which nothing happens. Our experience has always been that, on each particular run, a definite outcome always occurs: the detector either clicks or it does not click. There would never be a half response, either an entire photon arrives or else nothing happens. And two detectors never respond simultaneously (unless the source had emitted two photons within the resolving time of the detector; a further decrease of the source intensity will decrease the chance of such coincidences). Since the energy of a single photon is typically very small ($\approx 10^{-19}$Joule), a device is often designed to register the photon's appearance by utilizing the photon to produce a current pulse by means of a high voltage avalanche process [444]. *On-off* or *click-detectors* produce well-defined "clicks" when excited by any finite number of photons, which can only deliver information about the absence or presence of photons [445]. However, could the clicking of such detectors also constitute a quantum measurement problem event which requires distinguishing unitary and non-unitary processes based on the physics of quantum entanglement as developed and discussed in Chapters 3 and 4? Although they are not designed to reveal such a distinction, detectors do function using many of the elements that we can now appreciate as being involved in the precise formulation of the quantum measurement problem.