Quantar Technology *Mepsicron-II*[tm] *Series* Single-Photon Imaging Detector System

MODEL 2601B **TECHNICAL SPECIFICATIONS**, AUG 2001

Technical Specifications

General Information. The Quantar Technology Model 2601B Mepsicron-II [tm] Single-Photon Imaging Detector System is an ultra-low-light, single-photon-counting, position-sensitive optical detector system designed for scientific and analytical instrument applications. These Technical Specifications supplement the Technical Description which should be consulted for a full description of the product.

Radiant Quantum Efficiency and Spectral Response. The minimum guaranteed Radiant Quantum Efficiency (RQE) at specific wavelengths is shown for each available photocathode type in the following table:

Radiant QE / Dark Count Specifications

Type	Radiant QE, % Guaranteed Min	Max Dark Count, cts/sec, -25° C
Bialkali	12% @ 400 nm	50
S20	15% @ 400 nm	110
S25	10% @ 500 nm 1% @ 800 nm	350
Super S25B (Broad)	8% @ 500 nm 2.0% @ 800 nm	500
Super S25R (NIR)	4.8% @ 800 nm 0.5% @ 900 nm	500

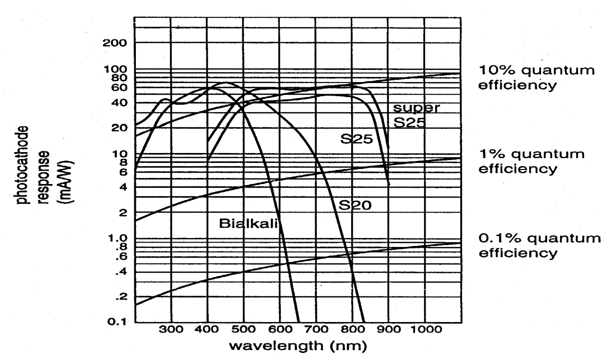
Radiant Quantum Efficiency (RQE) specifies the percentage of photons incident on the photocathode which result in generation of a photoelectron that can be detected by the system. Approximately 80% of the photoelectrons from the photocathode are captured by the first MCP (unfilmed MCP in Mepsicron-II version) and processed by the system. RQE measured at +25°C.

The imager photocathode type (photon-to-electron converter) should be selected by the user based on the spectral sensitivity and dark count requirements of the application. The photocathode is deposited on the inside (vacuum side) faceplate surface of each permanently-vacuum-sealed *Mepsicron-II* [tm] Imaging PMT Sensor Head and is not interchangeable.

The system can be provided with the users choice of photocathode types including a a bialkali type (blue-green sensitive, 180-600 nm); an S-20 type (extended blue-green sensitive, 180-700 nm); a broad-range S-25 multialkali-type, red-sensitive type (300-800 nm) and two *Super-Gen Enhanced S25* types (the R type optimized for red and NIR spectrum response (700-900+ nm) and the B type for more broadband response (400-800 nm)). Consult Quantar Technology for other photocathode types such as solar blind (CsRbTe). The photocathode types with higher red-spectrum sensitivity generally exhibit higher dark count.

QE of actual devices are typically somewhat higher than the minimum guaranteed QE specified in the table at left. Typical (not guaranteed) spectral RQE versus wavelength curves for various photocathode types are shown below. QE is measured on an average spatial basis over a large area of the photocathode and point-to-point variations of ±10% are typical but not guaranteed.

Typical Photocathode Spectral Response



Dark Count Background Rate. The table at left also shows maximum total dark count in defined 23 mm central active image area for each photocathode type at -25°C (excludes outer 1 mm rim of active area). Dark count background is primarily thermally-generated dark count from the photocathode, plus a small contribution from residual MCP background. Photocathode dark count depends on operating temperature and type of photocathode. Dark count is measured at STROBE output of readout electronics with no light input, at -25°C.

Dark count per XY pixel typically determines the signal-to-detector background ratio. To obtain average dark count per digital pixel, divide the total dark count by the number of digital pixels in active area diameter (approximately 823,000 25-micron square pixels in 23 mm diameter defined circular active area with 1024 x 1024 pixel XY digitization). Resulting typical dark count per pixel is approximately 10^{-4} to 10^{-5} counts per pixel per second, far lower than other imaging detectors. Compare this with expected detected signal counts per pixel to determine the approximate signal-to-detector background ratio. Detector background varies from pixel to pixel; some pixels will typically exhibit higher than average dark count; this variation is not guaranteed.

Spatial Resolution, X and Y. Intrinsic detector spatial resolution is specified at 65 microns FWHM spread function or better (typically 55-65 microns). Spatial resolution is defined as the FWHM distribution of the position jitter in the detector position output in response to a large number of photons focused in a infinitely narrow point source or line image on the photocathode. This resolution is equivalent to a minimum of approximately 400 *resolvable spatial elements* across the 25 mm active area diameter in both the X and Y axes. Resolution is measured at approximately 500 nm wavelength at low count rates. Spatial resolution is normally slightly better towards the red spectral region and slightly poorer towards the blue-UV region for any single photocathode type.

Maximum Permissible Detected Photon Rate. This system is a counting-type detector system, optimized for ultra-low-light (low photon count rate) levels. A finite dead-time is required to elapse after each detected photon event before the next photon can be accurately processed. The maximum permissible photon count rate is determined by the basic system event-dead-time of 4 microseconds per detected photon (with 256 x 256 channel XY digitization of image). For uniform time rate-of-arrival of photons, this is equivalent to a maximum permissible count rate of 1/4 usec = 250,000 counts/sec. For random (Poisson) distributed photon arrival times (incurred in typical real-world applications), this maximum output count rate is reduced and a defined percentage of incoming photons are not processed. The maximum imaged output event rate is 100,000 photons/sec (which occurs at a detected input photon rate of 250,000 photons/sec, a 67% photon coincidence loss). At lower input count rates, the coincidence (dead-time) losses are progressively smaller, so the output rate more closely tracks the input count rate. Even at lowest count rates, some coincidence losses will occasionally occur due to two photons arriving very close together in time given random time-of-arrival statistics.

For 512 x 512 or 1024 x 1024 pixel digitization of the image, the per-event dead-time increases to 6 usec and 10 usec respectively. The effect on the maximum output count rate (random-arrival) is shown in the table below (and dead time curves following).

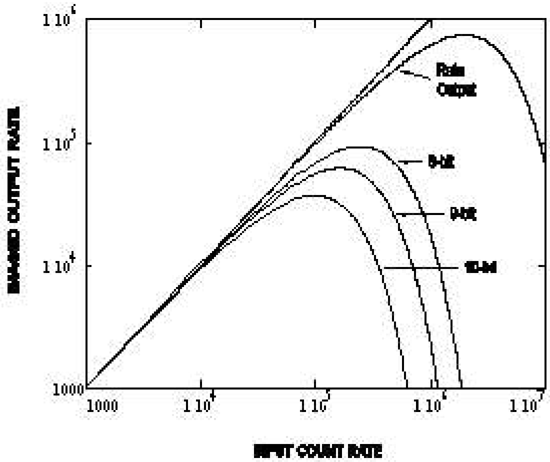
Maximum Achievable Count Rates

Image Digitization	Dead-time per event	Maximum Imaged Count Rate
256x256 or analog output only	4 μsec	100,000
512x512	6 μsec	65,000
1024x1024	10 μsec	50,000

Note that the *detected* photon rate is always lower than the actual *incident* photon rate striking the photocathode since the radiant QE (photon conversion efficiency) is less than 100%. Consequently, the actual maximum permissible incident photon count rate striking the photocathode can be higher by 1/QE (typically 10X depending on wavelength) than the maximum permissible imaged detected count rate specified in the table above.

If desired, the imaged output count rate can be normalized to correct for global dead time losses in some types of applications, by using the non-imaged RATE output signal, which linearly tracks the actual raw detected photon input count rate quite accurately to above 100 KHz as shown in the System Count Rates figure below. This plot also shows the deviation (dead-time loss) of the XY imaged output count rate from the ideal straight line as a function of input count rate, for 256, 512 and 1024 channel pixel digitization on each axis.

SYSTEM INPUT-OUTPUT COUNT RATES



Other effects on maximum detectable count rate may be encountered for photon flux focused in very small (less than 0.4 mm) geometrical areas of photocathode such as from narrow point or line sources, based on MCP (microchannel plate) local gain saturation effects. Maximum photon count rate for a 100 micron wide x 3 mm high image detail is typically several 1000 counts/sec.

Other Characteristics/Features

Thermoelectrically-Cooled PMT Housing. Imager tube in thermoelectrically (TE)-cooled PMT housing is normally operated at a temperature of -20 to -25 degrees C. Standard TE-cooler will achieve a minimum imager tube temperature of at least 35 degrees C (typically 40 deg C) below temperature of user-supplied cooling water circulated through housing (or cooling air in optional air-assisted TE coolers). To achieve this temperature, user must supply chilled cooling water of appropriate temperature (typically not warmer than +15 deg C or colder than +10 deg C depending on options selected), with flow of approximately 40 liters/hour (10 gallons /hour). Extra-capacity TE coolers are optionally available which achieve a minimum 55 deg C (typically 60 degree C) temperature differential. Closed-loop recirculating water chillers are optionally available.

Minimum (coldest) recommended operating temperature of imager tube is -25 deg C (bialkali type photocathodes may exhibit higher QE at minimum of -20 deg C).

Focal-plane position of detector (active photocathode surface) mounted in the standard TE-cooled housing is adjustable from 33 to 42mm measured from front mounting surface of TE-cooler housing (physical not optical path distance). An optional TE cooler is available that is adjustable from 65-70 mm.

Mechanical adapters are available for mounting to selected spectrographs.

HV Supply/Voltage Divider/Overcount Trigger Module. The HV divider provides operating voltages for imager and also includes electronic sensing circuits to electro-optically shutter imager photocathode if detected count rate exceeds preset count rate limit. Photocathode is normally operated at approximately -3000 volts and position-encoder-anode (RAE) of imager tube at ground potential. Grounded photocathode input configuration is optional, consult factory. A high-voltage power supply with preset output voltage is included. An external rack-mounted HVPS can be optionally provided.

Imager Faceplate/Cooler Window. Imager has UV-grade fused-silica (quartz) faceplate with high (approx 80%) transmission from 180 nm to beyond 1000 nm, 6 mm thickness. The TE-cooled PMT housing itself is equipped with a vacuum-evacuated, double-pane, UV-grade, fused-silica insulating window positioned in front of the imager tube. Surfaces (4) of this insulating window can be optionally anti-reflection (AR) coated to optimize transmission at specified wavelengths or wavelength ranges.

Active Photocathode Area. Nominal 25 mm diameter circular active detection area, 490 mm^2. Defined active quality imaging diameter is 23 mm. Defects (e.g. higher dark count areas) may occur outside 23 mm quality diameter.

Electronic Pulse-Pileup Rejection. Circuits are incorporated to maximize spatial imaging accuracy at maximum count rates. Photon events arriving too close together in time to be accurately imaged (but separated by at least 400 nsec) are vetoed (locked out) from processing to optimize image quality. System uses a fifth, fast look-ahead preamplifier channel for this pulse-pile-up rejection timing.

RATE output (a TTL level pulse) tracks total count rate, enabling determination of coincidence rejection losses (STROBE output tracks only imaged events).

Analog X and Y Outputs. Separate 0-5 volt analog position pulses are available, with amplitude linearly proportional to event position on X and Y axis, for each processed photon. For use as input to real-time photon image display (user-supplied lab oscilloscope or analog display monitor with 2 channel, 0-5 V input X-Y mode and compatible Z axis blanking) and/or to external ADC's (see MCA Adapter option to translate levels for typical external ADC's). Use of real-time display monitors have proven very useful in applications and are strongly recommended.

Digitized X and Y Outputs. Fast, 130 MHZ clock-rate Wilkinson-type digitizers produce parallel 8, 9 or 10 bit (factory-set) digital position data for both X and Y axis for each processed photon, in addition to analog signal outputs. Data is parallel, TTL positive-true, latched; accompanied by digital strobe signal. Digitized photon output data from successive photons is typically histogrammed (summed by position, one by one) in external digital memory and/or data system to form images.

Electronic Window Controls. Four front-panel, 10-turn controls (+X, -X, +Y, -Y) enable user selection of "electronic" active image area of detector from which photon counts are accepted. Enables selection of desired portion of image for data acquisition or exclusion of unwanted data (e.g. exclude spatial areas where no signal exists to reduce dark count output to data system).

Veto Gate Input. External TTL signal can be used to gate processing of output data from detector system based on external events. TTL-high signal is normal operation; TTL-low activates gate (interrupts data flow).

Front Panel Meter. Displays approximate total raw count rate, % dead-time coincidence loss rate, average MCP gain (to enable setting of HV bias). Switch-selectable meter function on front panel.

Weight. Shipping weight: Approximately 90 lbs (40 kg) depending on options selected.

Environmental. Designed for operation in laboratory environment, 20 to 23 deg C ambient temperature, controlled humidity, stable power line source. Maximum operating or storage temperature of imager tube without damage: +50 deg C, minimum temp -35°C.

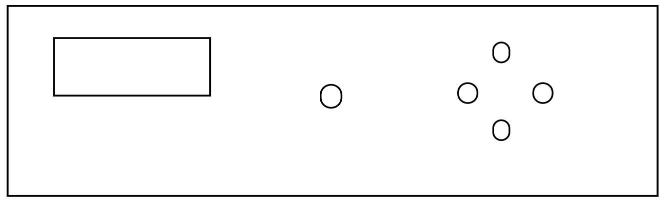
Power Required: 110-120 VAC, 50-60 Hz, 500 watts. Option 070: 220-240 VAC, 50-60 Hz, 250 watts. Typical, depends on options selected.

Dimensions/Other.

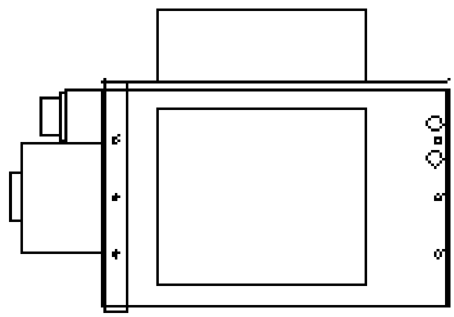
Model 2401B Position Analyzer: Electronics unit, full-width rack module: 5.25" H x 17" W x 18" D (133 x 432 x 560 mm).

TE Cooled Imager Housing, Preamp Module and Voltage Divider Module: Mounted on TE-cooled PMT housing: 10" x 10" x 14" HWD (255 x 255 x 355 mm) approximately rectangular outline. Separate control module.

HV Power Supply: Integrated into HV Module. Other formats available.



2401B Position Analyzer



TE-Cooled Housing - Side View - HV Divider mounted on top, preamp on side. Photons enter from right side into front of housing

Mkgt-PC:WP8\QTIDS\2601B\TechSpecRevE.wpd

QUANTAR TECHNOLOGY INCORPORATED
2620A Mission Street, Santa Cruz, CA 95060
Tel: 831-429-5227 FAX: 831-429-5131
www.quantar.com