VACUUM COMPATIBLE DETECTORS

GICS-75 – A 75 mm active diameter MCP detector fibre optically coupled to a Photon Counting ICCD Camera with 5 ns gating and synchronous 512 x 512 CCD and custom image processing software

FEATURES

- Custom CAD Designed
- Manufactured in Europe
- Integrated Detector Systems
- High Calibre Design Team
- Ultra High Speed
- Ultra High Resolution
- Detection of Molecules, fragments, ions, antimatter, neutrons, leptons, hadrons, photons etc.

APPLICATIONS

- Mass Spectroscopy
- Electron Microscopy
- VUV Imaging
- Space Telescopes
- Fusion Research
- Nuclear Physics
- Field Ion Microscopy
- Measurement of Chemical Bond Strength
- Low Temperature Physics
- Synchrotron Radiation
- Photo Ionisation

INTRODUCTION

Photek is a small company of dedicated scientists and engineers engaged in designing, manufacturing and selling detectors to meet specific customers requirements. We have designed and built custom detectors for many of the major laboratories in Europe.

Photek detectors are used to measure picoseconds, nano-degrees Kelvin, anti-proton fluxes, molecular spin etc: the diversity is quite extraordinary. The following photographs and text gives some indication of the capabilities of Photek to design and manufacture custom detectors for the vacuum environment.
RESPONSIVITY OF VACUUM COMPATIBLE DETECTORS

The basic detector element is a microchannel plate (MCP). This is fabricated from a microtubular matrix of secondary electron emissive glass, and responds well to electrons, other charged particles. The approximate responsivity, collated from various published sources, is shown in Figure 1. The exact response depends upon many parameters including the angle of incidence of the charged particles and the history of the MCP. MCP vacuum baking sometimes reduces the responsivity but also reduces the noise generated by these detectors.

CsI coating will enhance the responsivity of an MCP, but as this is chemically reactive to moisture, it may be unsuitable for application where the detector has to be repeatedly exposed to air.

Powder scintillators are normally used to convert the electron output of microchannel plates to an optical output in Vacuum Imaging Detectors. Table 1 shows the time response and optical output of common powder scintillators.

VACUUM IMAGE DETECTORS

Photek holds stocks of 12, 18, 25, 40 and 75mm active diameter MCPs and fibre optic screen assemblies. The general schematic format is shown in Figure 4.

A typical assembly, VID240 is shown in Figure 3. This particular device is designed for UV spectroscopy, and used a 40/25 fibre taper outside the vacuum for connection to a linear diode array

Image Intensifier bodies can also be mounted directly onto a vacuum flange as shown in Figure 5. The device illustrated is part of an ultra high resolution photon counting UV imager with resolu-

![Image 1](image1)

**Figure 1 – Responsivity of Vacuum Int. Detectors**

Photek manufactures a wide range of image intensifiers, and the metal-ceramic bodies of these devices are often used as the basis for the Photek range of Vacuum Compatible detectors. Figure 3 shows a bare image intensifier adapted to be mounted on a vacuum manipulator M3 screw connector with flying high voltage leads and operated as a beam finder.

![Image 2](image2)

**Figure 2 – Vacuum Imaging Detector 340 (Radial Connectors)**

![Image 3](image3)

**Figure 3 – Bare Image Intensifier (VID125 & Flying Leads)**

![Image 4](image4)

**Figure 4 – Vacuum Imagers – Schematic Formats**

The inherent resolution of a scintillator screen on its own is typically 75 lp/mm. With one MCP, this is reduced to 30-40 lp/mm, but a gain of approximately 10^4 is achieved; with 2 MCPs, resolution is in the range of 20-30 lp/mm but the gain in the range of 10^5 to 10^7 is possible.

The gain and temporal response of the detector depends on the phosphor screen selected of which characteristics are shown in Table 1.

![Image 5](image5)

**Figure 5 – High Resolution UV Imager VID325 (Connected to blank flange assembly for transport)**
Table 1 – Phosphor Characteristics

<table>
<thead>
<tr>
<th>TYPE</th>
<th>COLOUR</th>
<th>PEAK EMISSION NM</th>
<th>DECAY TIME TO 10% BRIGHTNESS</th>
<th>EFFICIENCY (LUMENS PER WATT)</th>
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<tbody>
<tr>
<td>P11</td>
<td>BLUE</td>
<td>446</td>
<td>50 μs</td>
<td>10</td>
</tr>
<tr>
<td>P20</td>
<td>YELLOW/GREEN</td>
<td>540</td>
<td>50 μs – 10 ms</td>
<td>30</td>
</tr>
<tr>
<td>P31</td>
<td>GREEN</td>
<td>550</td>
<td>40 μs</td>
<td>25</td>
</tr>
<tr>
<td>P43</td>
<td>GREEN</td>
<td>548</td>
<td>1.2 ms</td>
<td>50</td>
</tr>
<tr>
<td>P45</td>
<td>RED ENHANCED WHITE</td>
<td>-</td>
<td>1.4 ms</td>
<td>20</td>
</tr>
<tr>
<td>P46</td>
<td>YELLOW/GREEN</td>
<td>530</td>
<td>160 ns</td>
<td>7</td>
</tr>
<tr>
<td>P47</td>
<td>BLUE</td>
<td>410</td>
<td>80 ns</td>
<td>2.3</td>
</tr>
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</table>

READEOUT SYSTEMS
Vacuum Image Detectors convert particles and high energy photons into visible images. These in turn can be converted into quantitative data by utilising a solid state detector such as a diode array or CCD camera. As Photek does not manufacture these items, we are pleased to sell our detectors on their own, or coupled to a readout system selected by the customer, with or without a frame grabber and image processing software.

Considerable experience of integrating cameras by EG&G, EEV, CIDTEC, Philips and Sony, has been gained. These devices mostly give an analogue TV signal and Photek can also provide A-D conversion electronics with or without photon/particle event software, and appropriate centroiding. Centroiding option allows this resolution of Vacuum Image Detectors to be enhanced to 3080 x 2304 pixels in the photon counting mode.

Our GM1KV gate module enables our Vacuum Image Detectors to provide time resolved images with frame exposure time down to about 100 nanoseconds.

Photek also manufacture streak and framing camera tubes for camera manufacturers with time resolution on the order of picoseconds.

RESISTIVE ANODE
This is the ideal readout for very low count rates, on systems requiring an X-Y address as well as event timing information. A two-dimensional resistive sheet encoder, specially terminated at the edges to reduce distortion, enables accurate charge cloud centroiding to be carried out by taking the ratio of the output signals from the four corners. Essentially this is a Ultra High Vacuum (UHV) version of the Image Photon Detector (IPD), and is sensitive to charged particles and UV photons. It can, therefore, be used for field ion microscopy and mass spectroscopy where the time of flight gives information on mass or molecular spin.

The Photek IPD processing electronics and image processing system are compatible with this detector. The support electronics encodes positions to a 512 x 512 of elements and operates at count rates up to 10^7 counts/seconds. As events positions are calculated in real time excellent spatial and temporal resolution can be attained.

Figure 6 shows a 40 mm resistive anode detector with ancillary head electronics built for high resolution VUV spectroscopy.

![Figure 6 – 40 mm Resistive Anode Detector Assembly with Preamplifiers](image)

VACUUM PHOTOMULTIPLIERS
These devices often described as Time of Flight (ToF) Detectors gives better temporal resolution than dynode electron multipliers or channel electron multipliers. The anode is designed with a matched cone structure to give sub-nanoseconds pulses from single photons or particles into a 50 ohm cable.

Our pre-amplifier PA 200-10 and discriminator electronics enable these devices to be connected to sampling scopes, or to provide event counting at rates up to 400 MHz.

Smaller devices are faster because the electrical signal has a shorter distance to travel, they have a lower capacitance (and thus shorter CR time constant). Typical performance parameters are shown in Table 2.

MULTIPIXEL PARALLEL READOUTS
Multi-anode devices are sometime required for high speed parallel channel detection. These are often designed to customer specific requirements: equal area concentric rings for Fabry-Perot interferometry are an example.

Photek has designs that are in regular production, and are shown in Figure 7.
### Power Supplies
Photek can supply a range of high voltage power units and systems compatible with its range of vacuum compatible imaging detectors.

### System Integration
Photek has all the capabilities for customising and integrating them with cameras and other electronics to provide complete systems. Imaging software IFS216 can also be supplied.

### Availability of Flanges and Detectors
CF flanges are based on the established conflat® design in which a precision OFHC copper gasket is captured between two knife edge sealing surfaces. The vacuum interface devices are also available mounted on ISO and other ‘O’ ring sealed flanges with an equivalent tubulation to the CF mounted detectors.

#### Table

<table>
<thead>
<tr>
<th>FLANGE SIZES</th>
<th>DETECTORS</th>
<th>KEY:</th>
<th>AVAILABLE ON REQUEST</th>
<th>STANDAR</th>
<th>X</th>
<th>NOT AVAILABLE</th>
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<tbody>
<tr>
<td>COPPER SEALED</td>
<td>VID 12</td>
<td>☑</td>
<td>☑</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>CF38 (70 MM OD)</td>
<td>VID 18</td>
<td>☑</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>CF64 (113.5 MM OD)</td>
<td>VID 25</td>
<td>☑</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>CF100 (151.6 MM OD)</td>
<td>VID 40</td>
<td>☑</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>CF150 (202.4 MM OD)</td>
<td>VID 75</td>
<td>☑</td>
<td></td>
<td>X</td>
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</tr>
<tr>
<td>CF200 (202.4 MM OD)</td>
<td>VPM 8</td>
<td>☑</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>CF250 (305 MM OD)</td>
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<td></td>
<td>X</td>
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<td>X</td>
</tr>
<tr>
<td></td>
<td>VPM 25</td>
<td>☑</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>VPM 40</td>
<td>☑</td>
<td></td>
<td>X</td>
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</tbody>
</table>

**FIGURE 7 - MULTI-ANODE DESIGN**

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