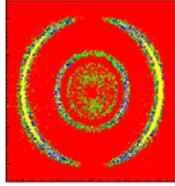


Beyond CCD...



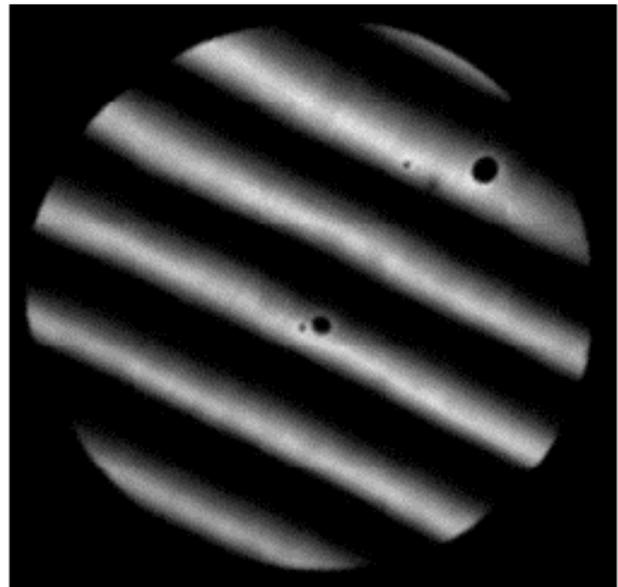
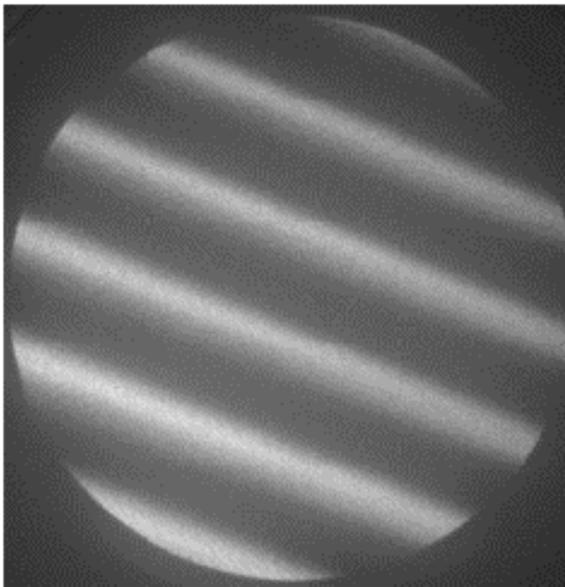
RoentDek
Handels GmbH

Supersonic Gas Jets
Detection Techniques
Data Acquisition Systems
Multifragment Imaging Systems

Microchannel plates (MCP) have the potential to detect single particles or photons with very good position resolution (< 0.1 mm) and time resolution (< 1 ns). Commercially, the most common read-out method is using a CCD camera that records the image from a phosphor screen behind the MCP: The electron avalanche from each detected particle is proximity-focussed onto the semi-transparent phosphor screen where it produces a photon shower. Each spot on the phosphor screen is imaged by optics (camera, fiber taper) onto the CCD chip. Its image information is read out with a certain frame rate (e.g. to a PC) so that individual pictures of the accumulated particle spots or picture sequences can be stored digitally.

The time resolution of this method is defined by the frame rate and thus applications with timing demands or involving fast dynamic processes would require special pulsing techniques. But even if just the imaging quality of an intensifying MCP is of interest there are good reasons *not* to use a phosphor/CCD combination behind but instead a single particle read-out method like the delay-line technique.

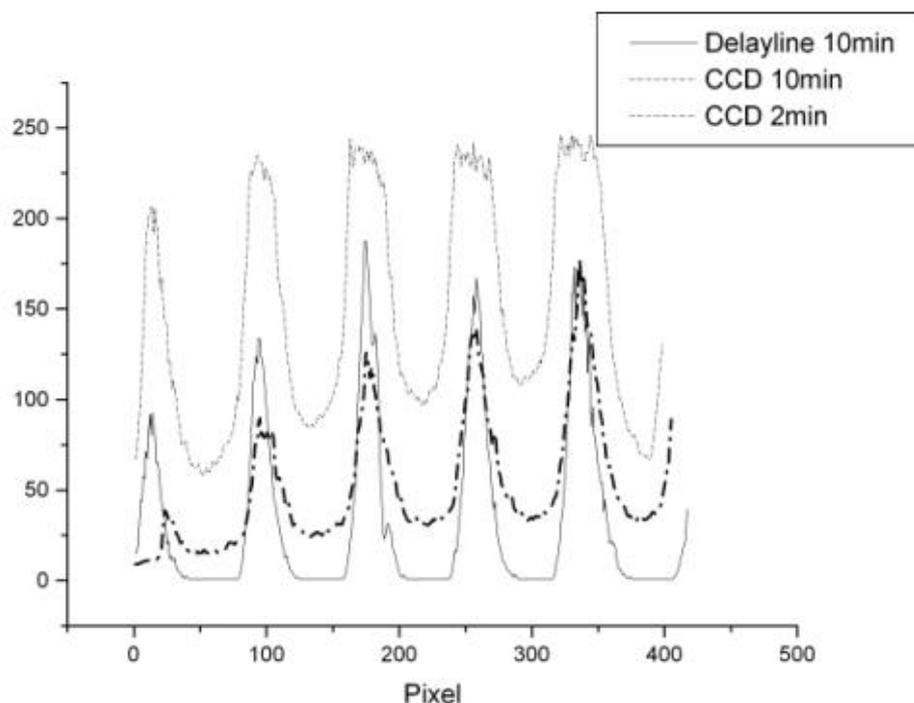
The figures below compare the performance of two sensors on a photo-electron emission microscope (PEEM). Sensors could be swapped from standard (single stage) MCP plus phosphor screen/camera read-out to a **RoentDek DLD40** delay-line detector. The sample was comprised of lithographically produced palladium strips on a silicon layer. Due to the choice of excitation energy only electrons from the palladium strips are emitted and thus one should obtain an image with high contrast (A. Oelsner et al., Rev. Sci. Instr. **72** (2001) 3968).



Images of a Si/Pd sample through a PEEM

Left: with single stage MCP, phosphor screen and CCD camera. Noise of the CCD chip blurs the image.

Right: with a RoentDek DLD40. The difference in contrast is obvious. Artefacts in the image are due to defects in the used MCP



Line scan through the Si/Pd strips. While the DLD40 maintains high contrast (no background) even over long exposure times, the CCD image suffers from noise in the "valleys", saturating in the "peaks" at longer exposure times (y-axis is scaled to same total intensities at 2 min. exposure time with CCD).

The comparison clearly demonstrates that the MCP with delay-line read-out maintains a high contrast even at long exposure times with negligible background, while the CCD read-out produces more image noise and soon shows saturation. Both effects contribute to a low image contrast (ratio between brightest and darkest areas).

Moreover, the delay-line method, as a true single-particle read-out technique, allows determining quantitatively the intensity (the number of particles). There are no uncertainties from an unknown efficiency of the phosphor or from losses in the optics and in the CCD, except for the quantum efficiency of the MCP itself, which is known for the respective particle/photon species or energy.

A single-particle read-out method like the delay-line technique will not add extra electronic noise or blur to the image. The minimum particle flux sensitivity is just defined by the MCP dark count rate of a few counts per second. A high-contrast image can thus be accumulated even for weakest intensities and over long exposure times. At typical intensities an image contrast of $1E5$ and better can be maintained with unlimited dynamic range.

Another major advantage is of course that the detection time of a particle can also be determined with precision below 1 ns which allows for precise time-of-flight measurement combined with position detection and coincident multi-particle detection on the same or on different detectors.

It should be noted, however, that single-particle detection techniques are limited to particle/photon fluxes below $1E7$ per second.

Combination between phosphor screen readout and timing measurement

It turns out that the rate limitations of true single particle readout technique sometimes calls for hybrid detector approaches that include a phosphor screen with CCD readout. Besides the global rate limitation of MCP stacks in pulse counting, there are also adverse dead-time effects of common single event read-out methods which are a challenge for pulsed operation modes, even if the averaged count rate may be modest.

An example for this is ionization by intense pulsed laser illumination at low repetition rate. Due to a larger of quasi-simultaneous particle hits per shot these can overlap in time domain, producing a broad signal contains time-of-flight information. Nevertheless, it may be required to also monitor the particle cloud's footprint on the detector in parallel.

For such experimental purposes **RoentDek** offers the **DET** timing detectors with optional phosphor screen.

Also, if optic elements needs to be tuned in microscope-type applications a fast optical feedback control at high flux operation may be mandatory, even if the actual experiment later is performed at low flux in single particle counting mode.

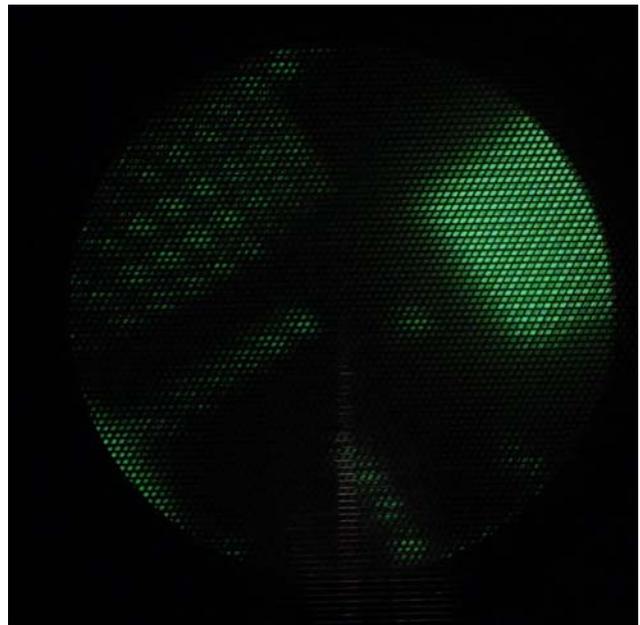
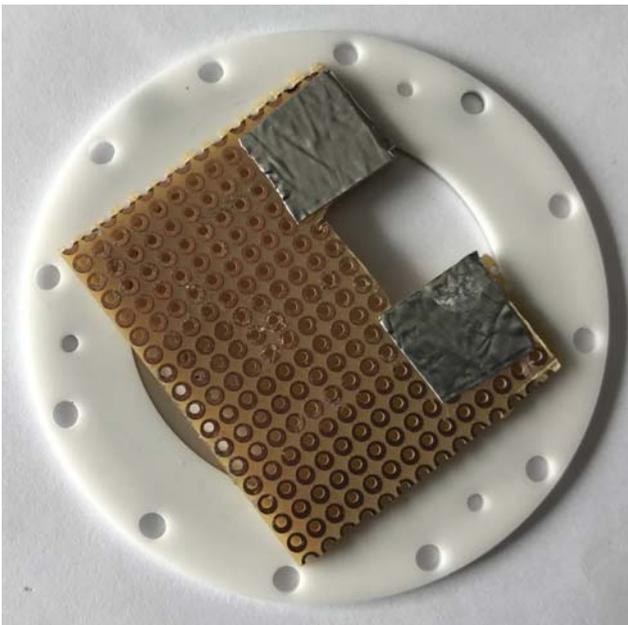
For this **RoentDek** can embed a phosphor screen into the **DLD** or **HEX** detector. Since footprint size on the screen is on the order 1 mm the spatial resolution for the optical control is very limited.

Internal report OJ 15.03.15

Test of embedded P43 in Hex40tms

here: without z-layer (corresponds to DLD40 with 60deg wire angle)

Test mask with 1mm holes at 2.5mm pitch, some hole rows were shaded during test.



Illumination: UV photons, MCP: Chevronset40eT 60:1, Camera : FUJI X10 (consumer type)