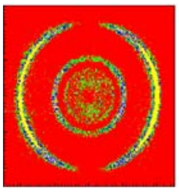
# Beyond CCD…

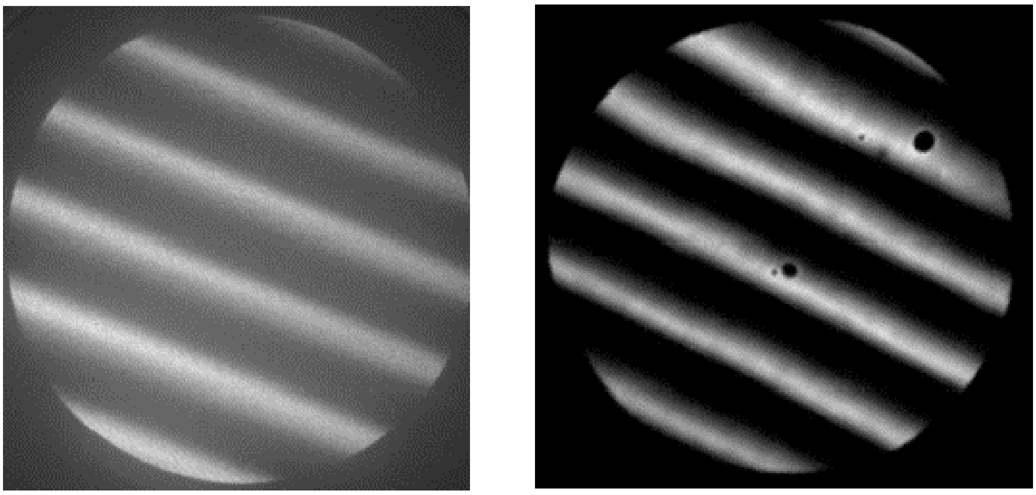


RoentDek
Handels GmbH
Supersonic Gas Jets
Detection Techniques
Data Acquisition Systems
Multifragment Imaging Systems

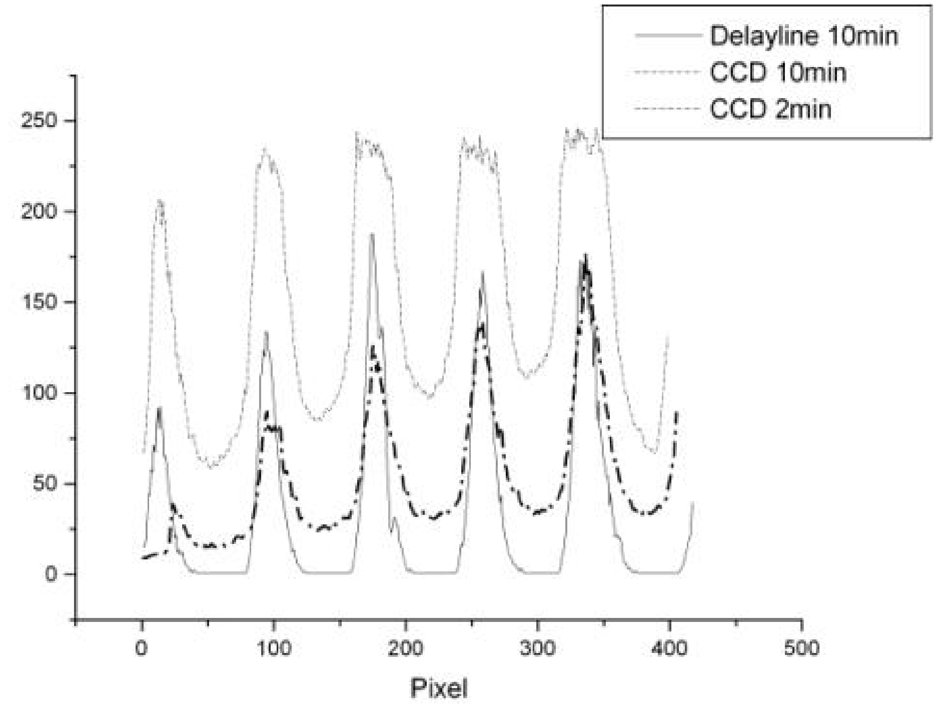
Microchannel plates (MCP) have the potential to detect single particles or photons with very good position resolution (< 0.1 mm) and time resolution (< 1 ns). Commercially, the most common read-out method is using a CCD camera that records the image from a phosphor screen behind the MCP: The electron 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 10e5 and better can be maintained with unlimited dynamic range.

It should be noted, however, that single-particle detection techniques are limited to particle/photon fluxes below 10e7 per second.