X-RAY PHOTON COUNTING CAMERAS

75 mm Gated X-ray Photon Counting Camera

FEATURES

- Single X-ray Photon Counting
- Close to 100 % Detection Efficiency
- High Spatial Resolution
- Very Low Dark Noise
- Adjustable energy discrimination levels
- Quantitative Measurements
- Gated Mode Operation

APPLICATIONS INCLUDE

- X-Ray Crystallography
- Nuclear Physics
- Laser induced X-Ray fluorescence
- Autoradiography

INTRODUCTION

This new camera incorporates energy discrimination, which enables far better discrimination between x-ray events and system noise. The x-ray scintillator is deposited directly onto the fibre optic input window of the image intensifier ensuring that every event is detected. For x-rays above 5 KeV, each x-ray photon generates a significant number of photoelectrons (10 or more) enabling x-ray events to be distinguished and thus separated from other noise in the system.

In general, the size of event scintillation's are much larger than dark noise events and may cover up to 30 CCD pixels. Special hardware and software allows the centre of gravity of the event using a centroiding technique to be recovered thus dramatically improving the system resolution. This also has the advantage that one detected event generates one count irrespective of the size and energy of the scintillation and thus allows truly quantitative measurements.

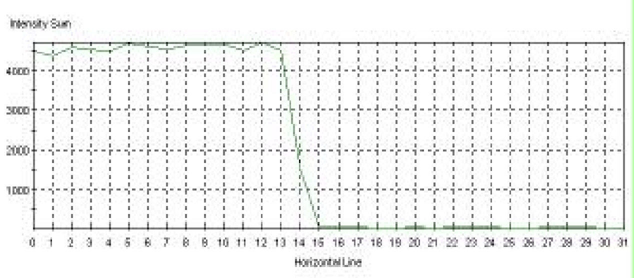
Centre of Gravity Detection

Special hardware and software process every frame of video data and detect the centre of gravity for every scintillation above a defined threshold using a centroiding technique. Thus for every event imaged, only one count is integrated into the image buffer irrespective of the size of the scintillation.

Positional and time information for each detected event may optionally be written to a disk file which may be analysed at a later stage. For example a sequences of images may be created. These may then be animated to show any changing states in an experiment.

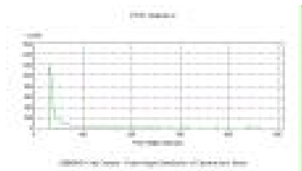
Edge Response and Resolution

The graph below shows the edge response of a mask. It clearly demonstrates the excellent resolving powers of the system as the signal drops from saturation to background (three orders of magnitude) in two CCD pixels – around 300 microns.



Pulse Height Distribution

The two graphs below show the PHD of the noise of the detector (left) and that when Fe55 signal is present (right). It can clearly be seen that the signal is easily discriminated from the background noise.



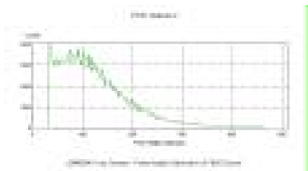
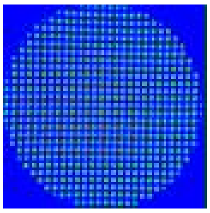


Image Distortion

This distortion image was acquired using a piece of electronic prototype board 13 mm in front of the scintillator and an Fe55 source 130 mm from the board. Distortion measured over a 70 mm active area is better than 5%. The active diameter shown in this picture is 76 mm.



Outline Specification

Active Area	76 mm Diameter for the DM80
Detected QE	Better than 80%
Scintillator	Gadolinium Oxy Sulphide
Dark noise	Less than 30 cps total - *This can be substantially reduced if a pulsed laser source and gating techniques are used.*
Image Size	512x512 pixels
Pixel Size	150 microns
Distortion	Less than 5%
Uniformity	Better than ± 10% from mean
Countrate	Greater than 100,000 counts per second
Countrate	1 count per pixel per frame
Frame Rate	Dependant on CCD camera (25 Hz,30 Hz,50 Hz or 60 Hz Options)
Detectors	DM80040 set to 76:25 magnification MCP325 Image Intensifier
CCD Camera	EEV CAM17 30 Hz Asynchronous
PC Interface	Photek Real Time Centoiding (PCI Bus)
Software	FS32 (Windows 95/98)

GaAs Diffraction Pattern[1]

Diffraction pattern from GaAs (111) with a laser-produced plasma pulsed X-ray source. The more intense line corresponds to Kα1 (1.540 Å), the weaker Kα2 (1.544 Å). X-ray pulses have a duration of the order of less than a pico second, at repetition of 20 Hz.

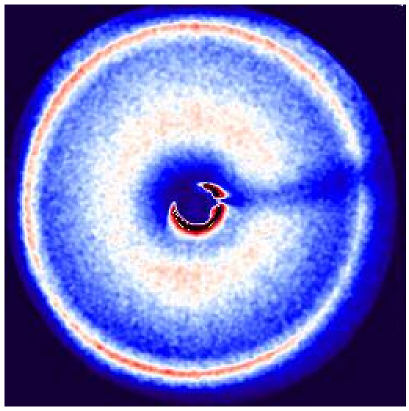
Single Frame Unprocessed Data

Integrated Image Using Centroiding Technique to Improve Resolution

As can be seen from the two images above, the camera can be operated in either an analog or digital mode. In the analog mode each video frame is digitised to 8 bits and displayed as a grey scale image. Alternatively, the image can be digitally processed using the centroiding techniques and a high resolution image can be integrated over time.

Diffraction Pattern from Nickel Foil [1]

The above image shows a diffraction pattern from 20 um nickel foil with a laser-produced plasma pulsed X-ray source. The X-ray pulses



have a duration of the order of less than a picosecond, at repetition of 20 Hz. The nickel is 30 cm away from the source, and the front scintillator is 4.0 cm away from the foil. The bright ring in the middle consists of unblocked direct X-rays. The outer most sharp ring corresponds to diffraction by nearest neighbouring Ni atoms, and the more diffused ring at smaller angles by the second and subsequent higher order nearest neighbouring atoms.

Camera Options

Demagnifier	Diameter	Pixel Size
DM47	45 mm	90 microns
DM80	76 mm	150 microns
DM150	140 mm	275 microns

Image Size	Format	Frame Rate
EEV CAM17	512x512	30 Hz
EEV CAM17	512x512	60 Hz
CCIR Non-Interlaced	288x384	50 Hz
CCIR Interlaced	768x576	25 Hz

Gating	Demagnifier 200 s MCP325 <100 ns
Time Resolution	Event Co-ordinates and time frame time information can be written to a disk file for further analysis.
Scintillator	Can be optimised for different energy x-rays

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[1] Images courtesy of Dr Ting Guo, The Wilson Group, University of California San Diego