CR (PSP) & DR (Flat Panel) Imaging Systems ; A Primer

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Presenter ;

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Section 1 ; Imaging Technologies CR/DR

Section 2 ; Exposure Indices

CR (PSP) Imaging Systems ;
@ Lancaster & Carlisle

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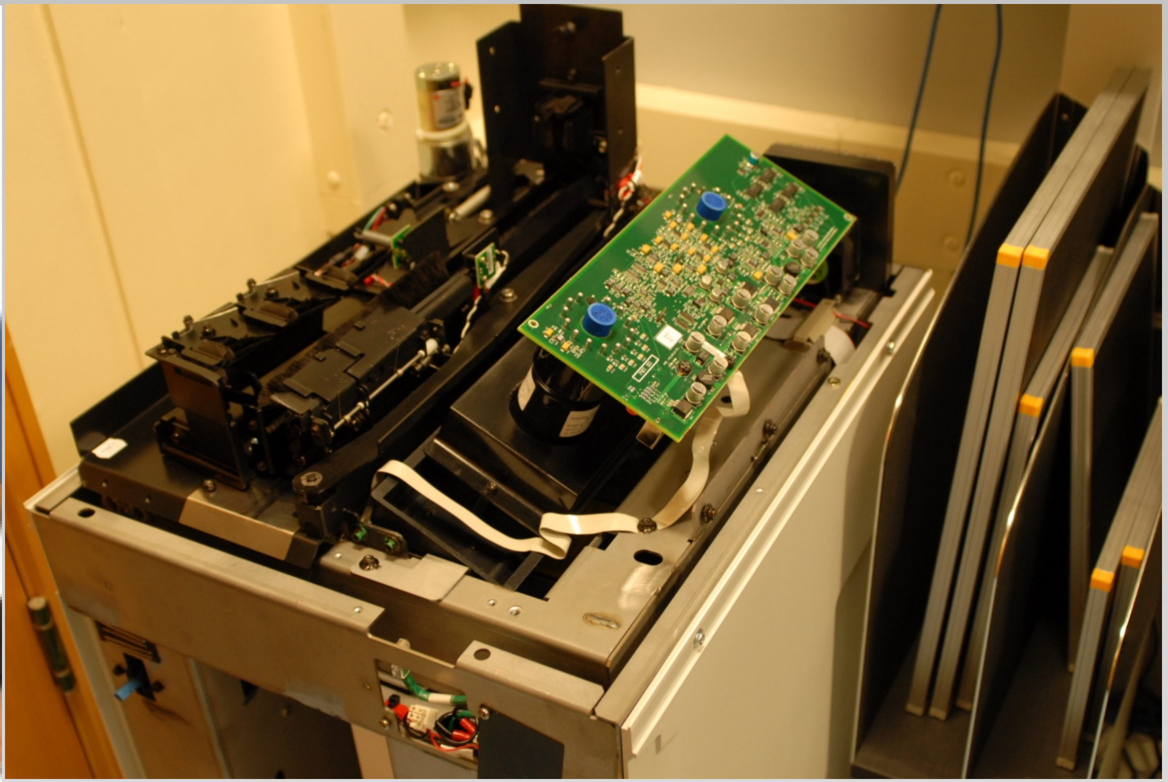

CR Technology

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The CR phosphor;

A CR plate is based on a fluorescent screen and housed in a conventional ‘cassette’

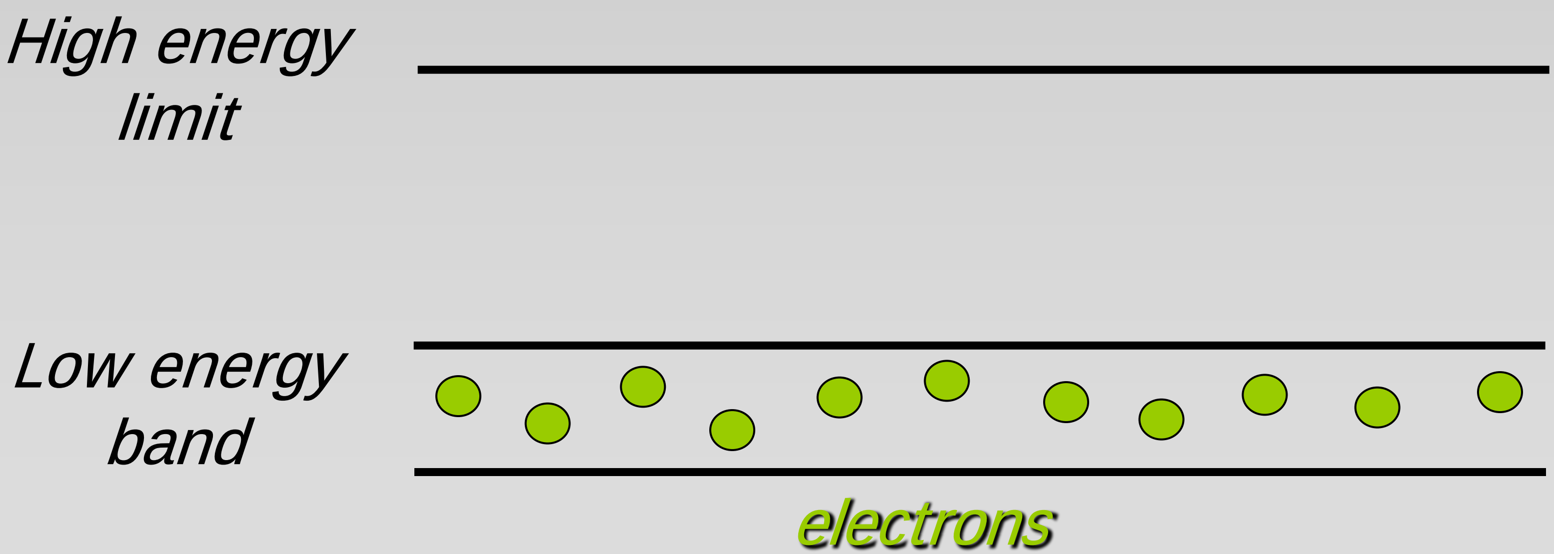
Most CR systems use a Barium Fluoro-bromide phosphor,

This is then “doped” with Europium

The Europium changes the chemical structure of the phosphor to “trap” electrons on x-ray exposure

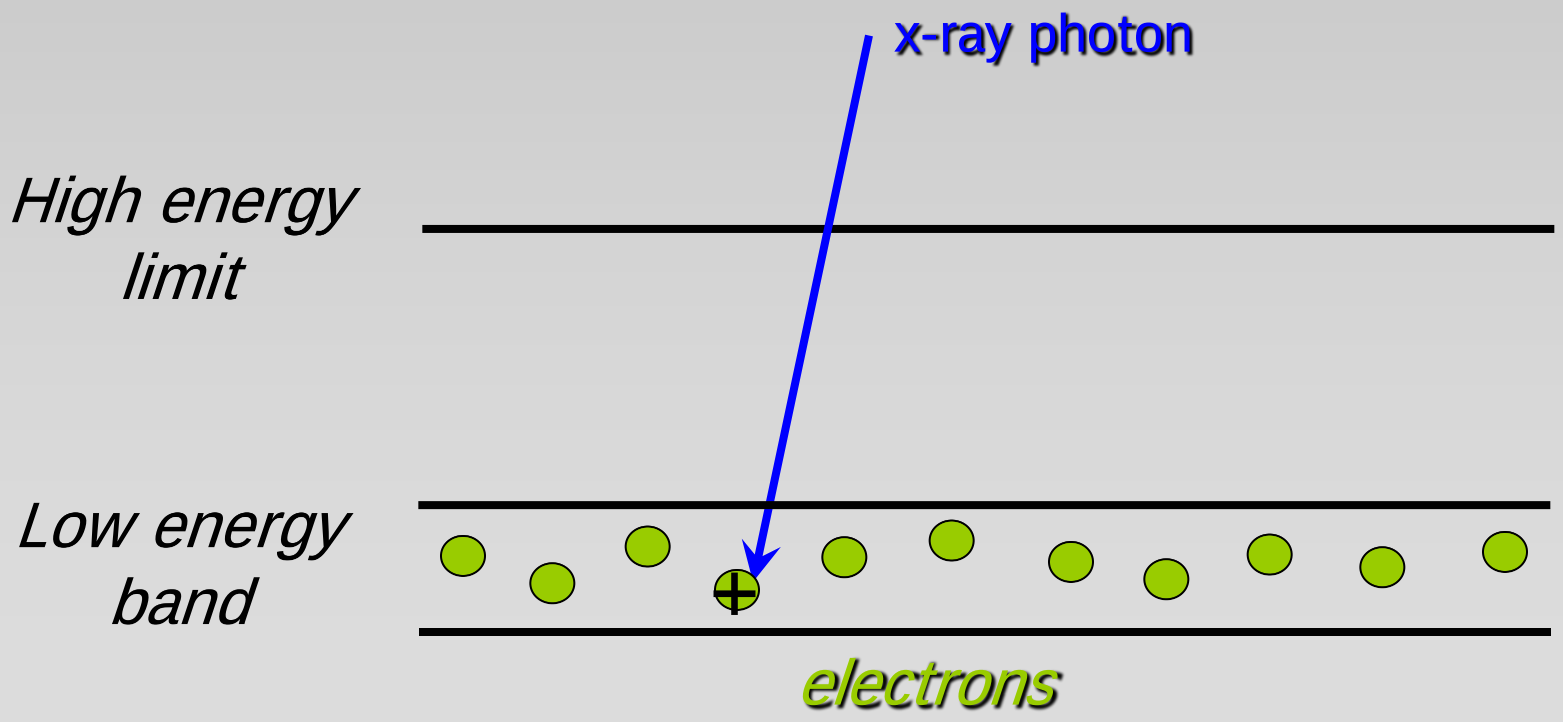
CR (PSP) Imaging Systems ; CR phosphor

In a fluorescent screen ; K shell electrons are normally ‘bound’ within a low energy band within the chemical structure of the screen phosphor



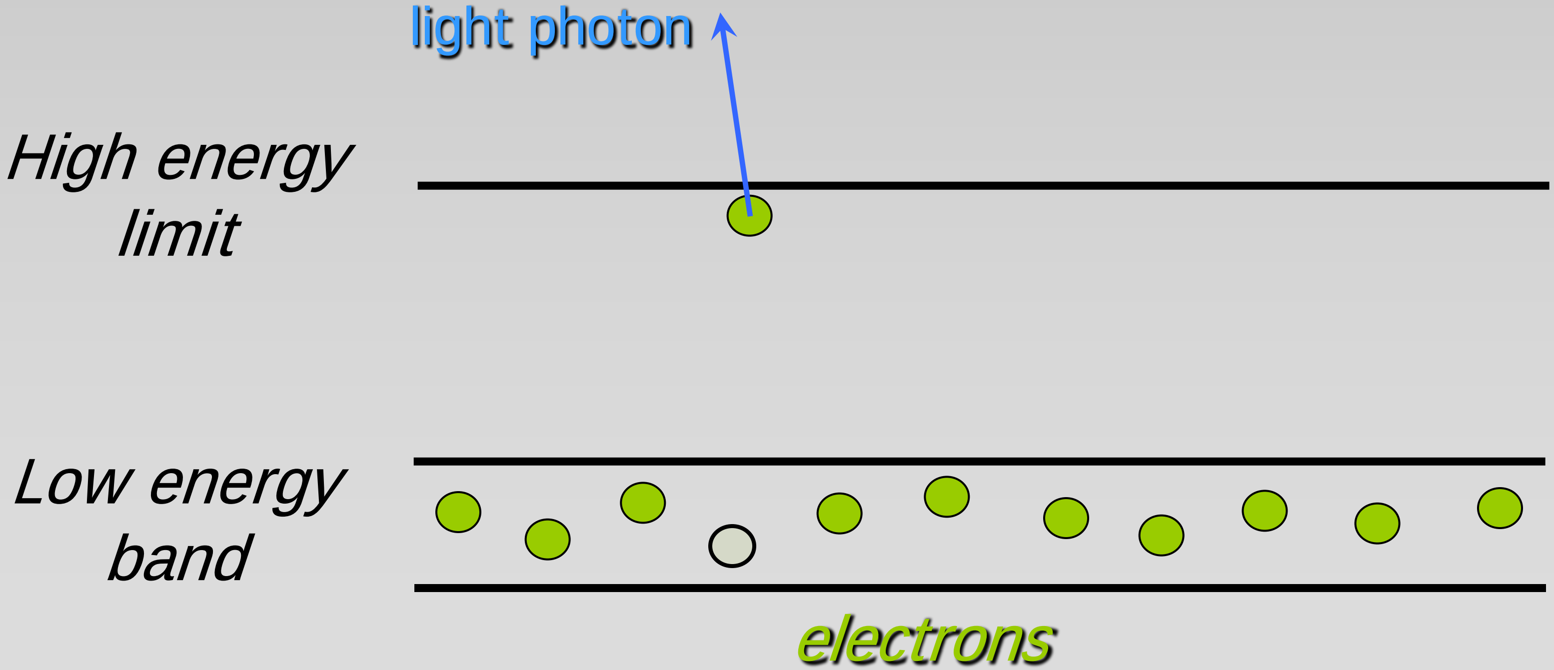
CR (PSP) Imaging Systems ; CR phosphor

When donated energy by an x-ray photon, electrons can ‘jump up’ to a higher energy level



CR (PSP) Imaging Systems ; CR phosphor

However, they leave a positive ‘hole’ behind them and will gradually fall back giving off the energy they gained as light



CR (PSP) Imaging Systems ; CR phosphor

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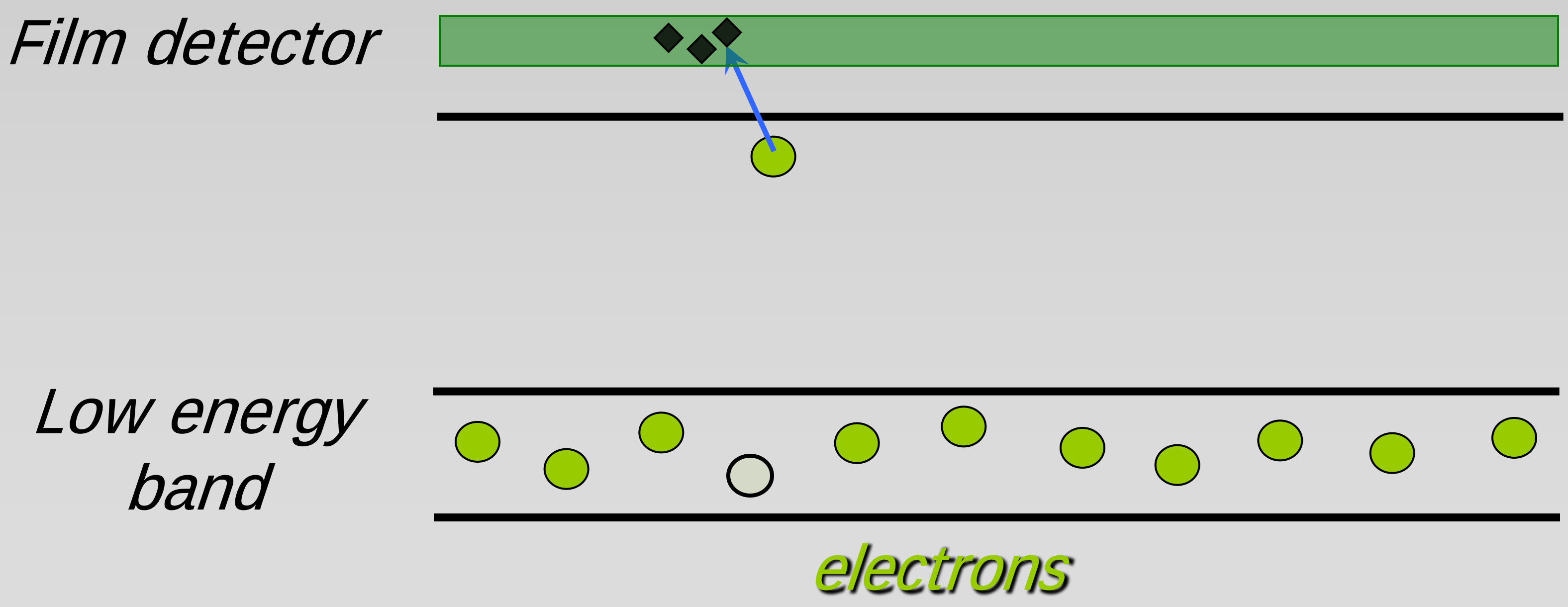
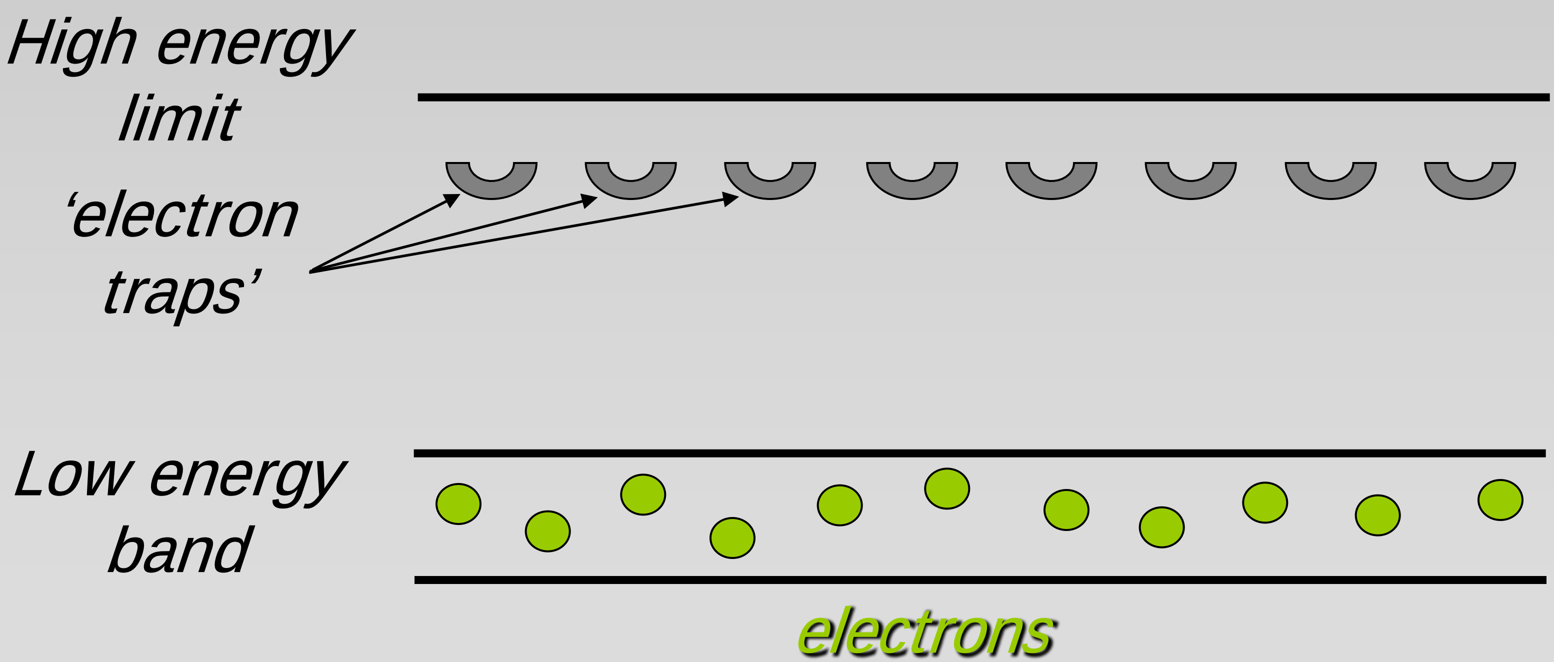
In a film imaging system we captured the light using photographic film, the light forming 'silver centers' in the emulsion, 'the latent' image



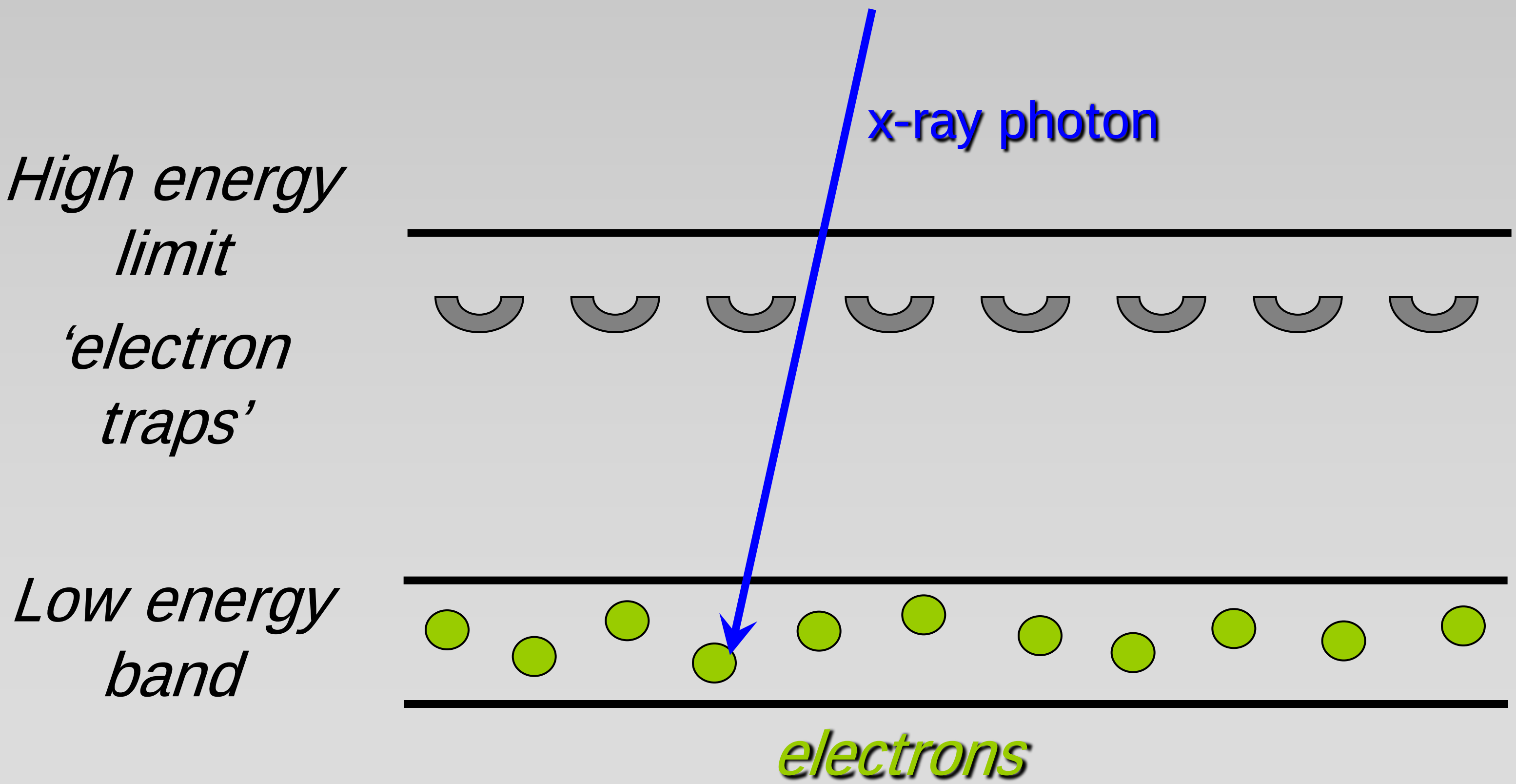
CR (PSP) Imaging Systems ; CR phosphor

In a CR phosphor, an impurity is added which creates ‘positive’ holes in the higher energy band



CR (PSP) Imaging Systems ;
CR phosphor

In approx. 50% of interactions, the electron is trapped



CR (PSP) Imaging Systems ; CR phosphor

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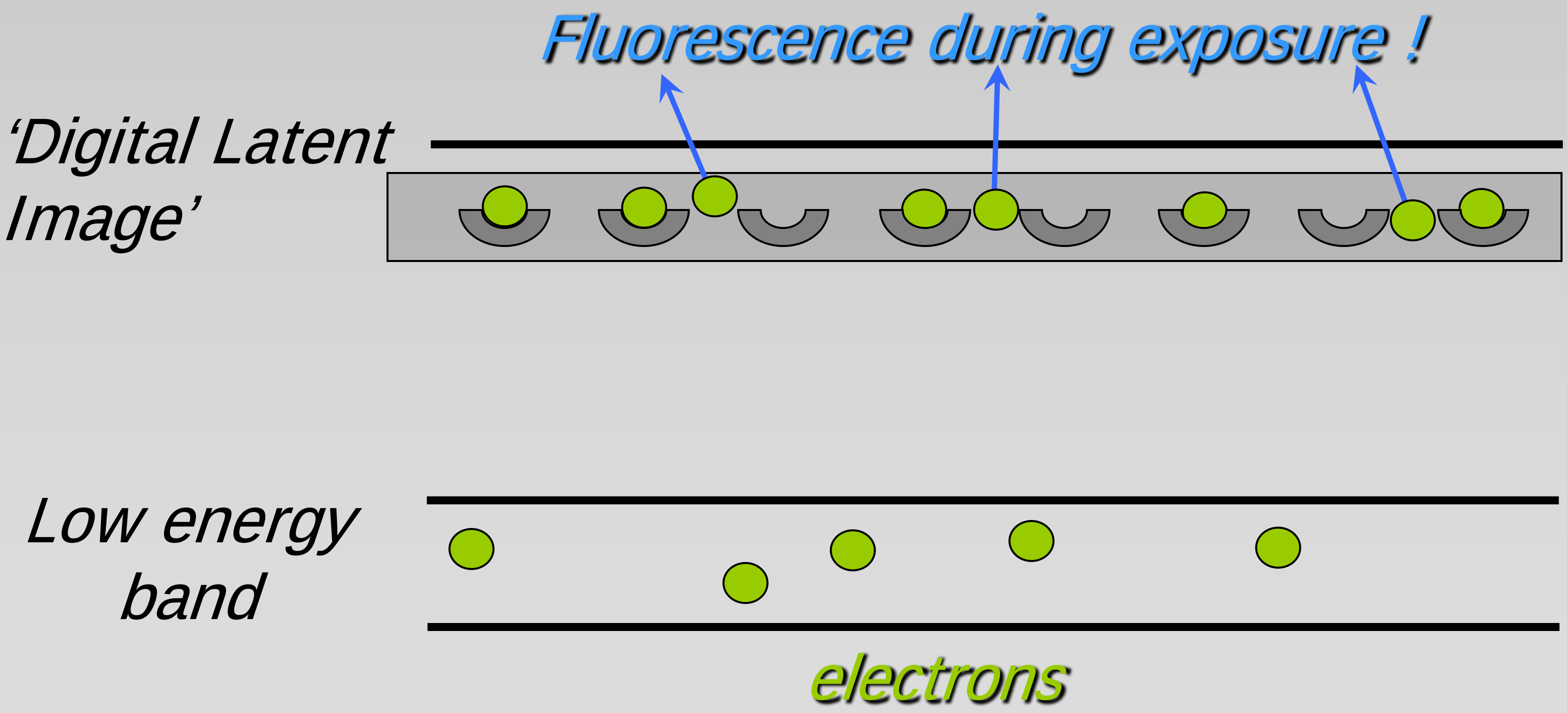
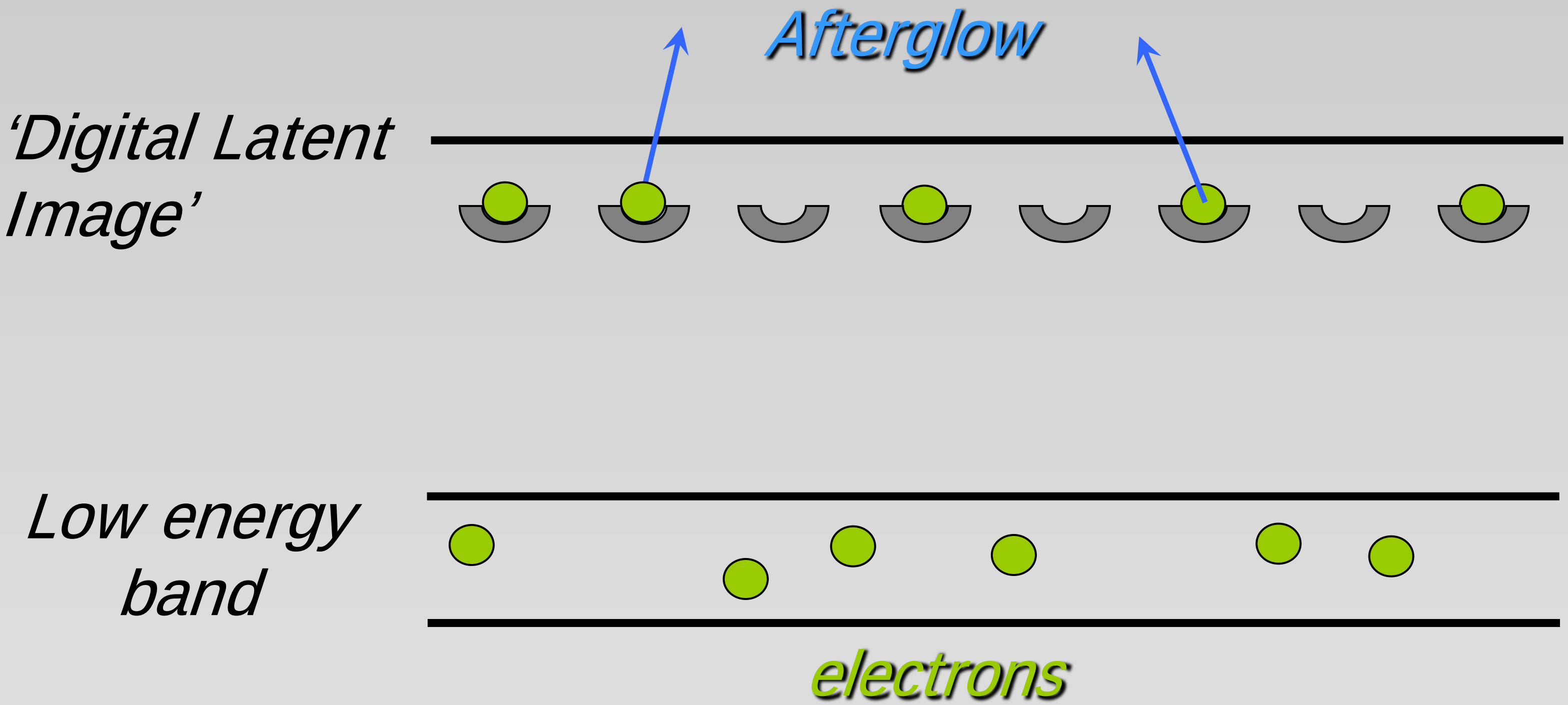
During and after exposure, about 50% of the electrons remain trapped, the rest fall back almost immediately



CR (PSP) Imaging Systems ; CR phosphor

Over time, due to thermal energy, trapped electrons fall back spontaneously over many hours



CR (PSP) Imaging Systems ; Laser scanning

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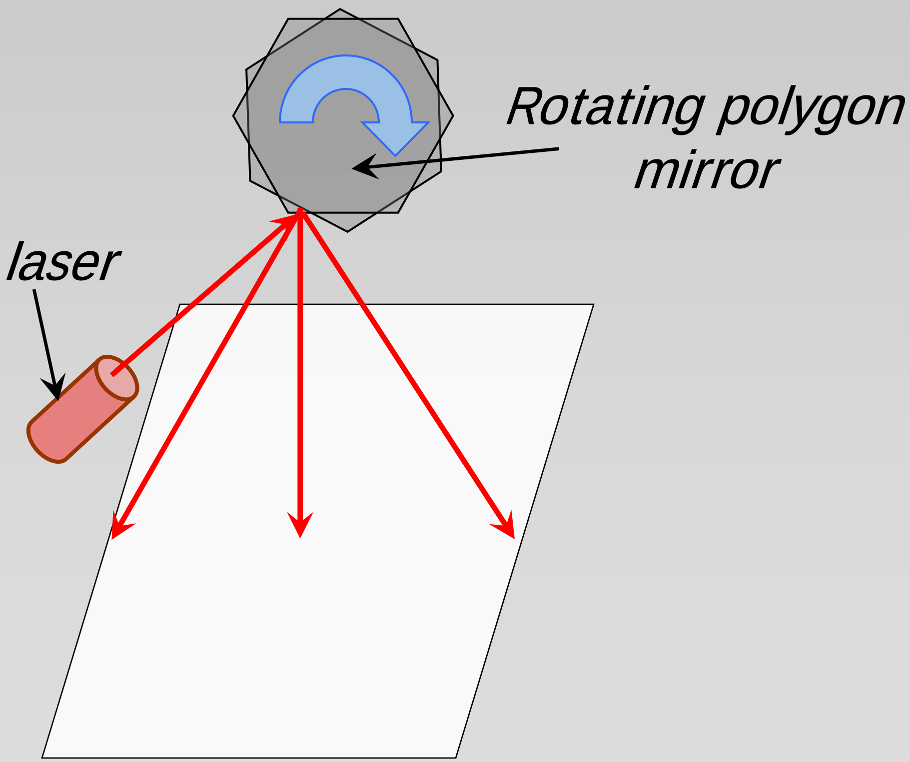
- As the laser scans, electrons are released from each pixel location, which produces photons of blue light. These are fed into the photomultiplier tube via a fibre-optic light guide.



CR (PSP) Imaging Systems ; Laser scanning

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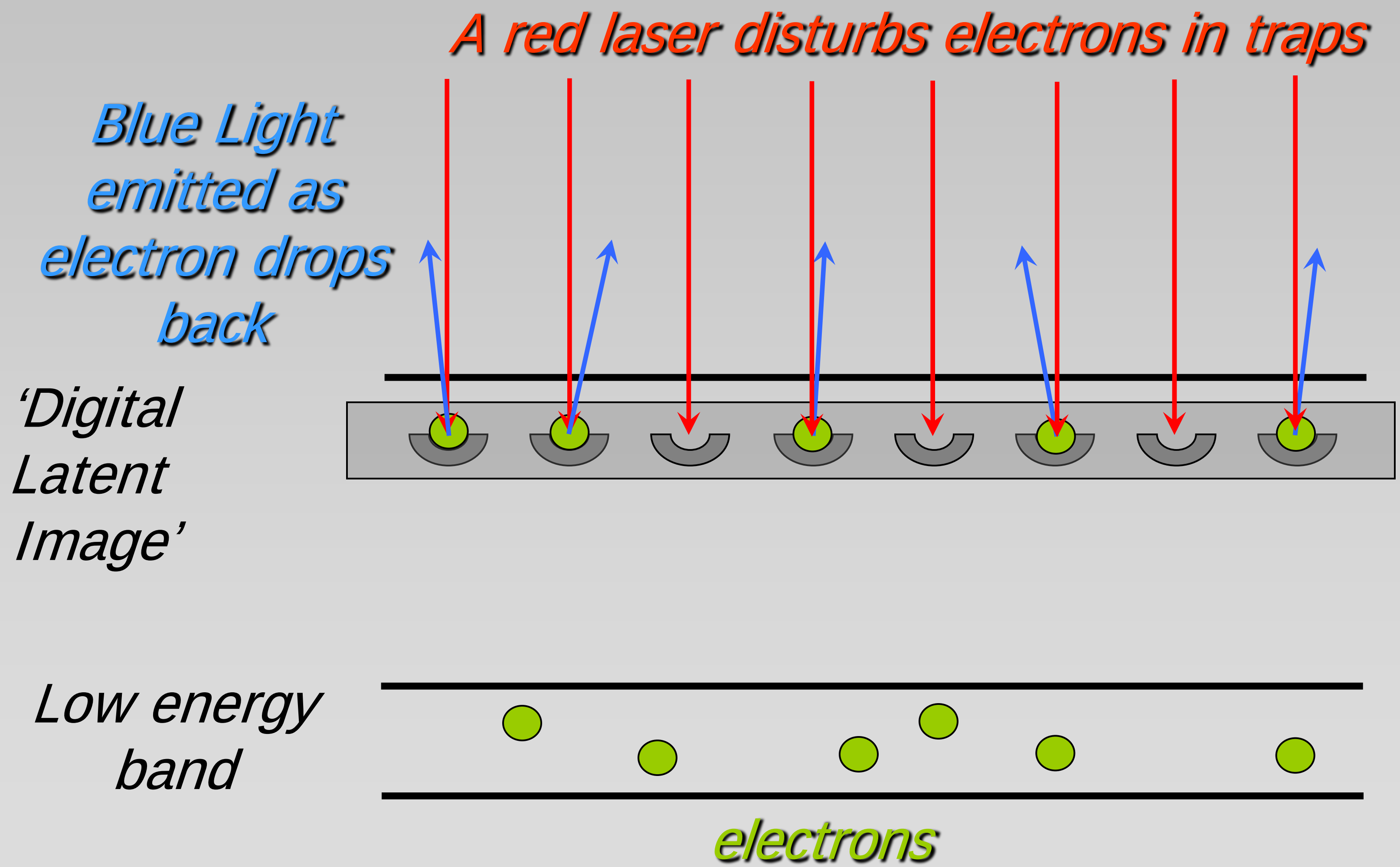
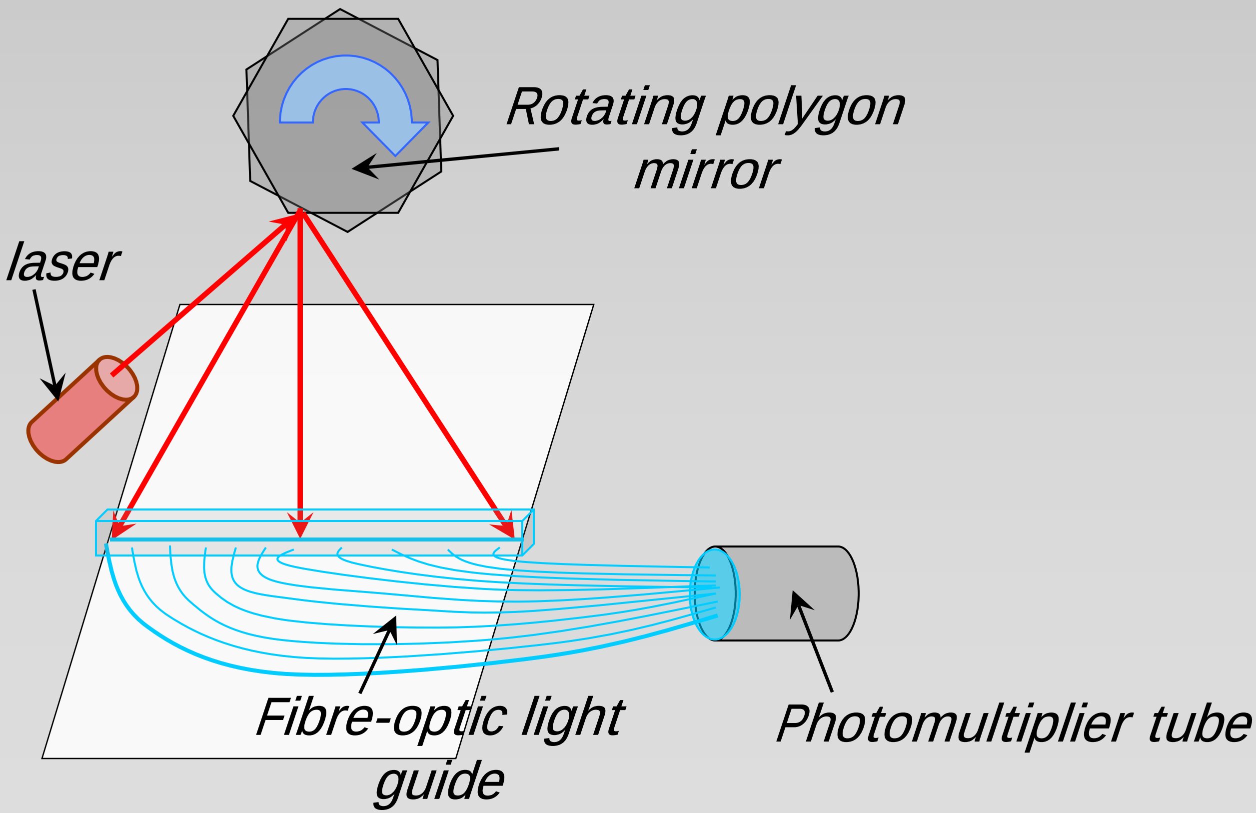


CR (PSP) Imaging Systems ; Photomultiplier Tube

As the laser scans, electrons are released from each pixel location, which produces photons of blue light. These are fed into the photomultiplier tube via a fibre-optic light guide.



CR (PSP) Imaging Systems ; Photomultiplier tube

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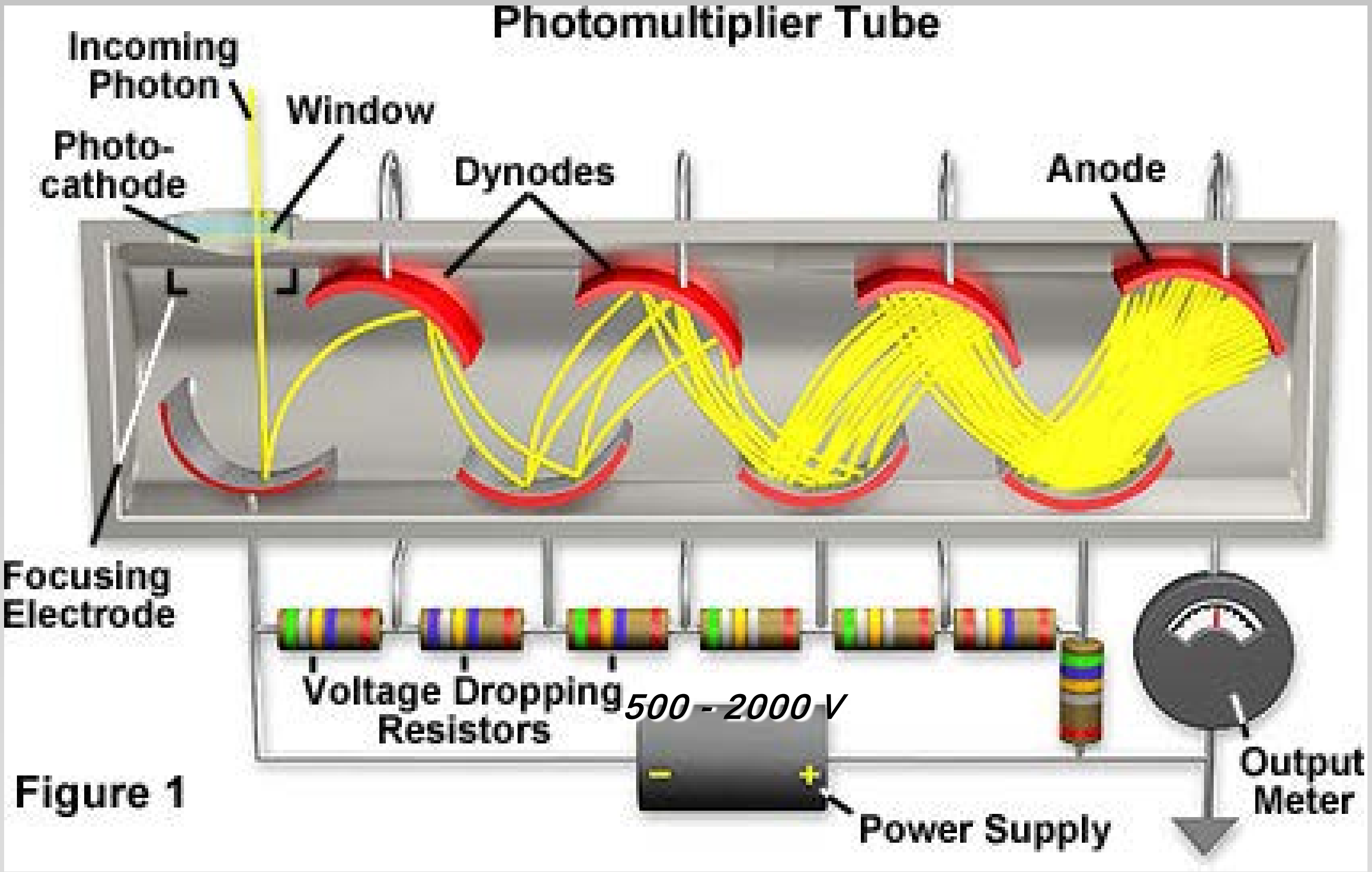

http//micro.magnet.fsu.edu

CR (PSP) Imaging Systems ; PMT Spectral response

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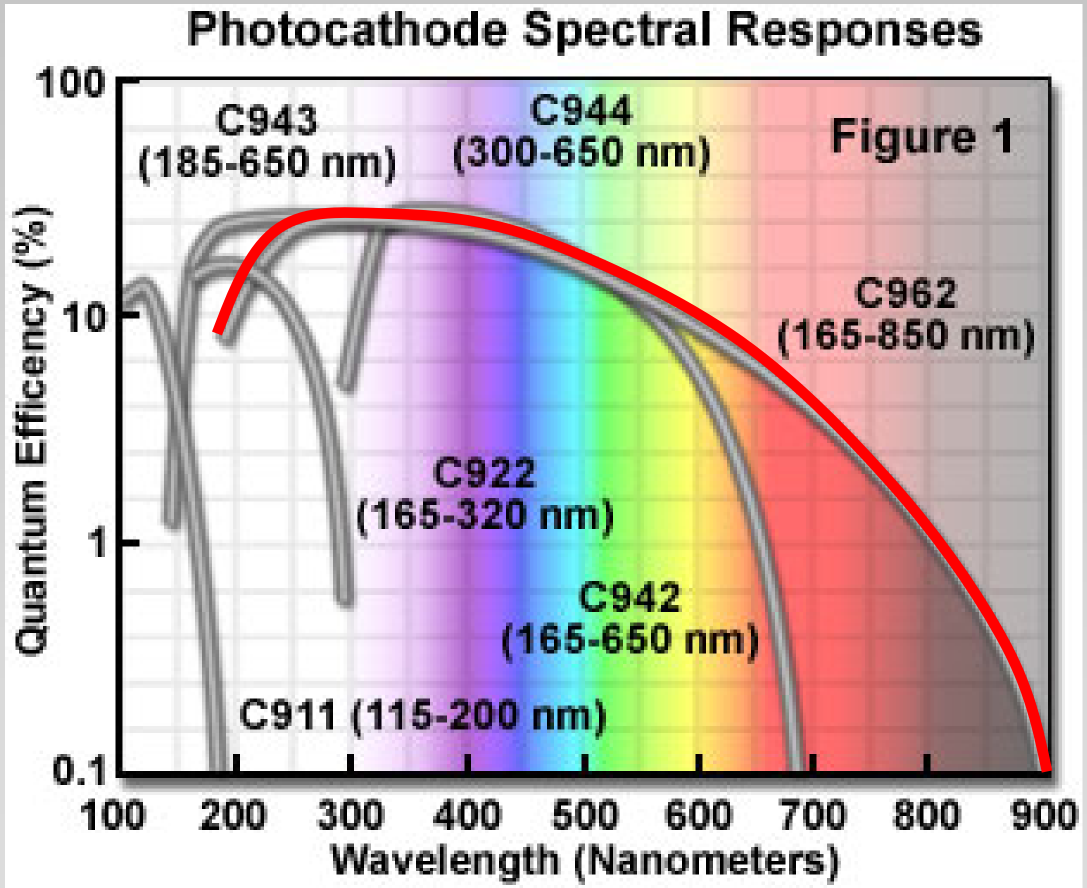

The coating applied to the photocathode is crucial to the spectral sensitivity of the device, for instance this coating would respond to both red and blue light.

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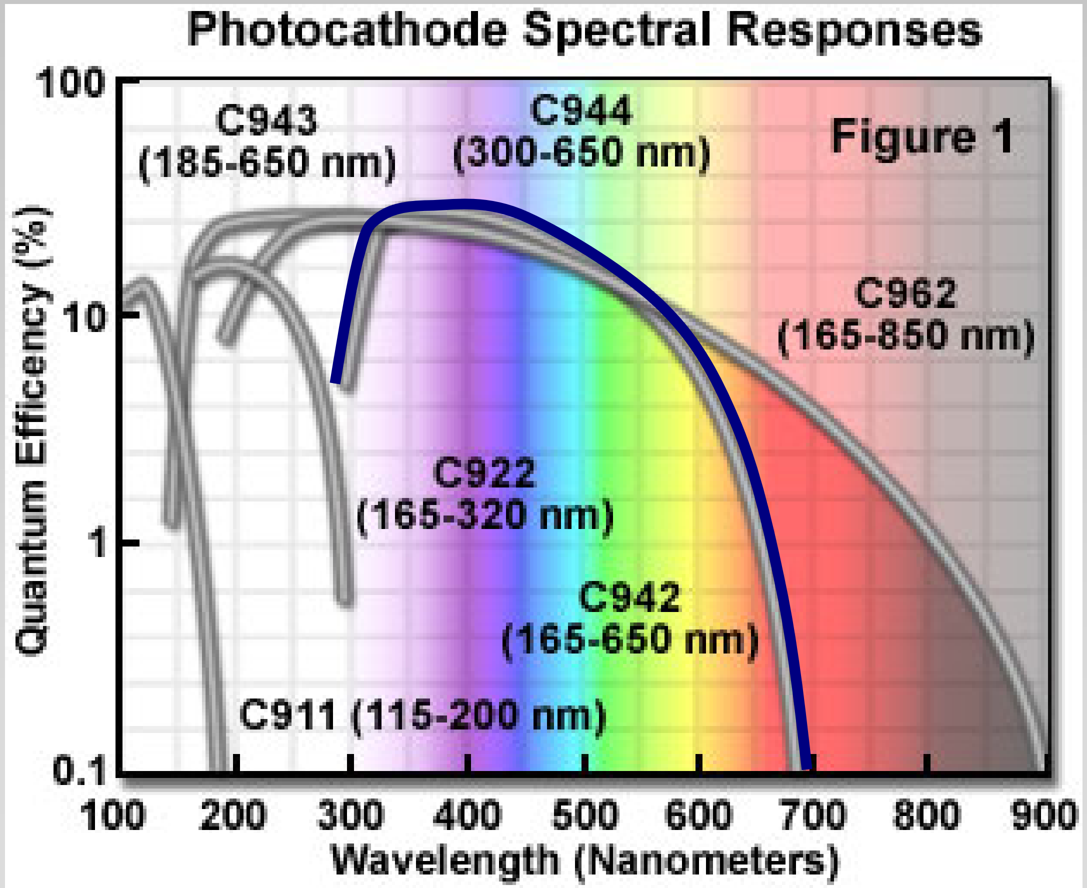
CR (PSP) Imaging Systems ; PMT Spectral response



The second coating would be better as the response to red light is very poor.

Across the whole spectrum, however, QDE is generally low, and never more than 35%

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CR (PSP) Imaging Systems ; Image Matrices

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As the laser scans, electrons are released from each pixel location, which produces photons of blue light.

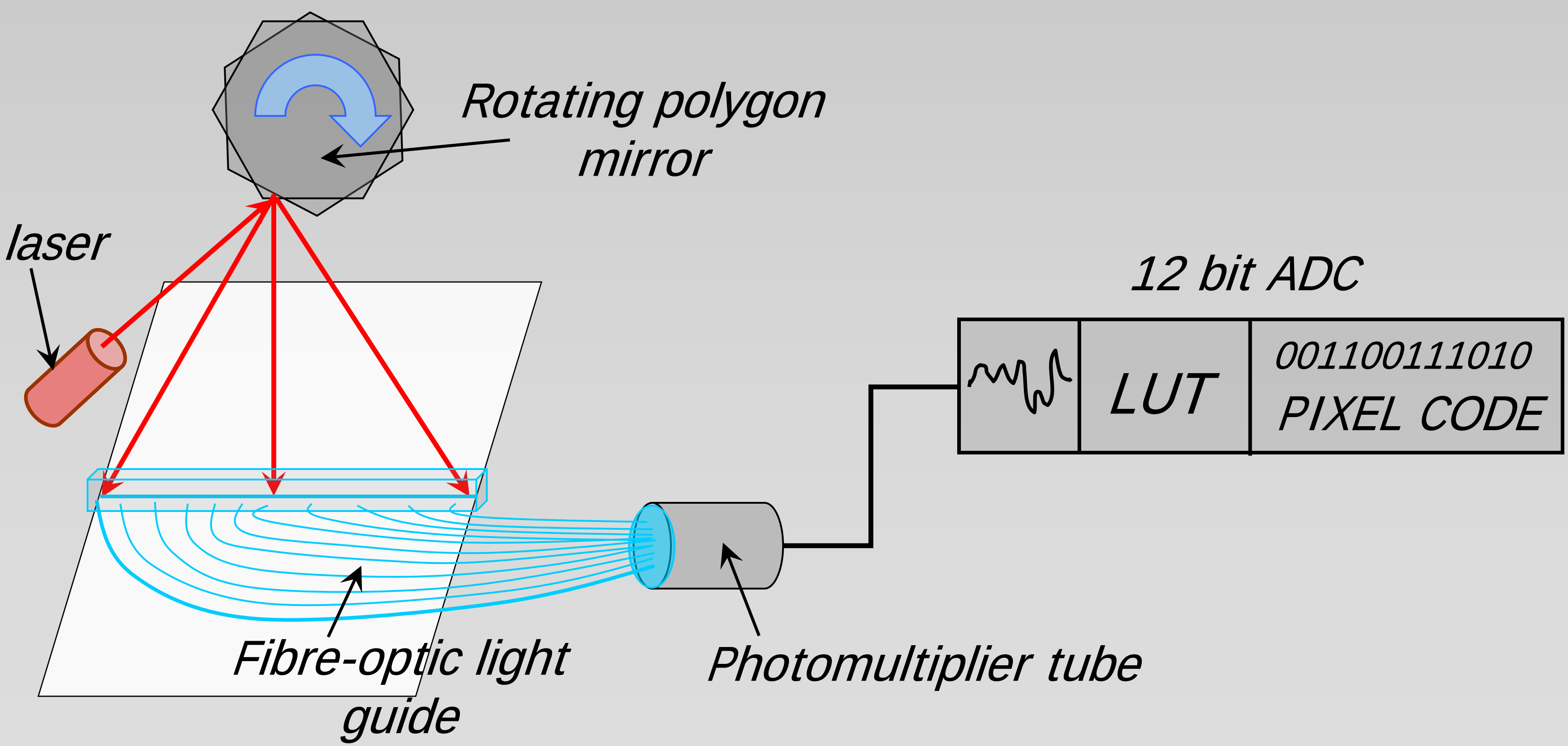
However, the speed at which the laser scans the plate is variable. For a given ‘quantisation rate’ in the ADC, the pixel matrix obtained can be related to the size of the plate used.

Plate size mm	Pixels in x	Pixels in y	X / Pixels in x	Y/ Pixels in Y
350 x 430 [x,y]	2072	2520	0.17 mm	0.17 mm
240 x 300	2400	3020	0.10 mm	0.10 mm
180 x 240	1792	2392	0.10 mm	0.10 mm

As shown in the table above ; the pixel matrices have been altered according to psp size, giving smaller pixels using small plates compared to the largest plates, for similar overall scan times.

CR (PSP) Imaging Systems ; Digital image processing

As the laser scans, electrons are released from each pixel location, which produces photons of blue light. These are fed into the photomultiplier tube via a fibre-optic light guide.



CR (PSP) Imaging Systems ;
Digital image processing

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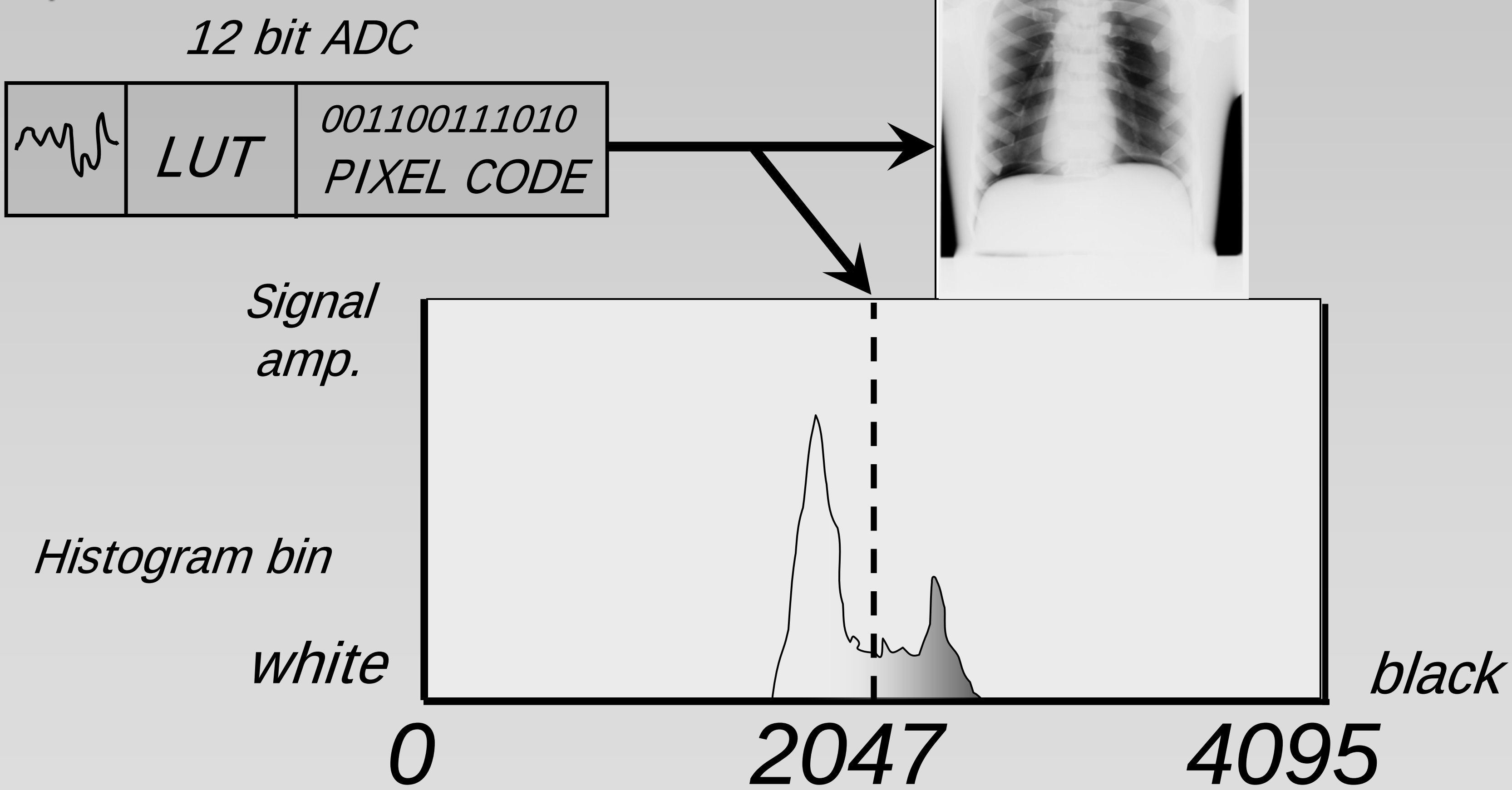
At a known mAs the histogram should fall in the middle of the range yielding the 'optimum' EI value for that manufacturer



CR (PSP) Imaging Systems ; Phosphor anealing (erase)

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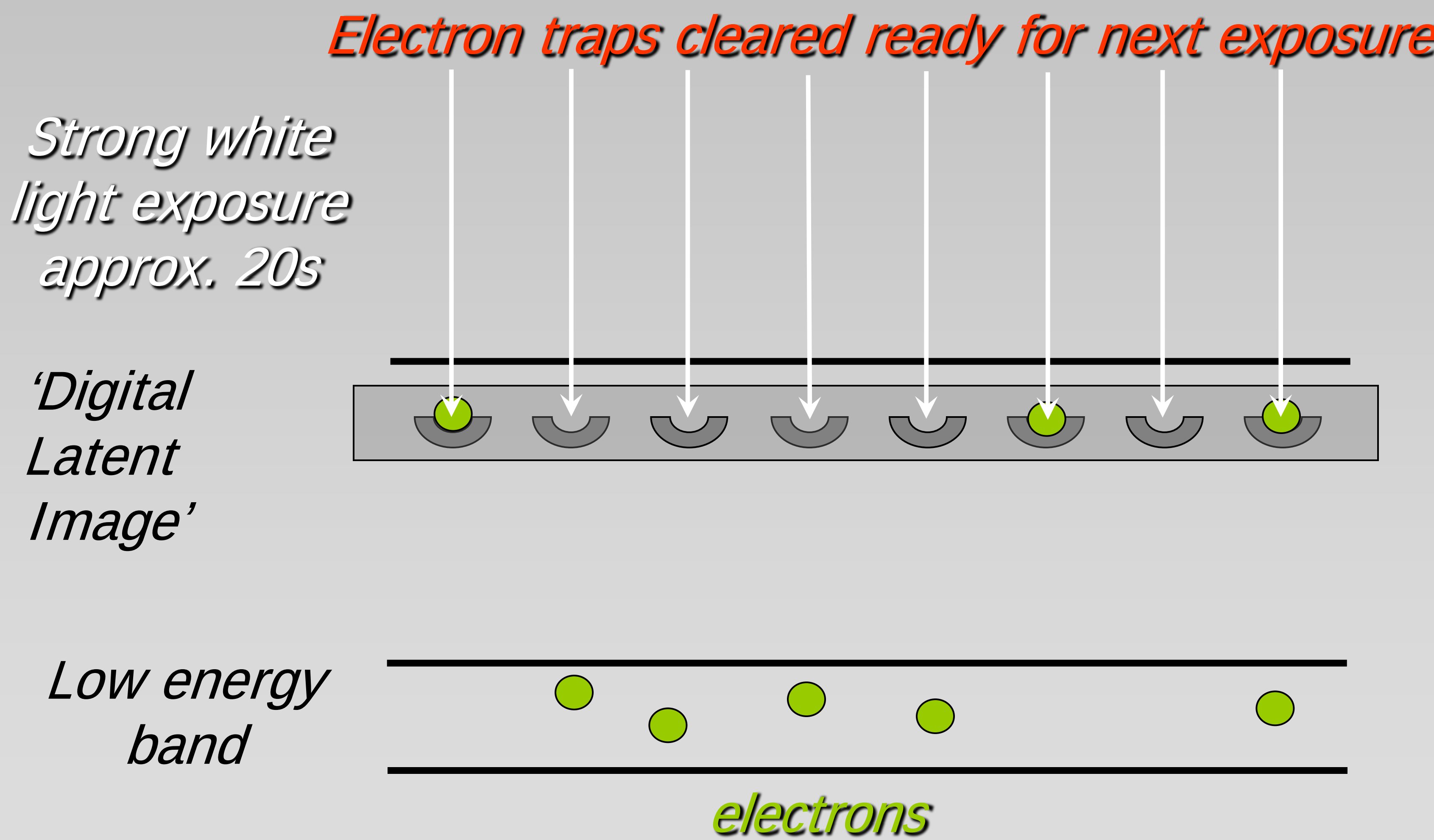

Image Acquisition - DR

DR Detectors ;

Are multiple coated TFT’s, in a large ‘flat plate’ format

Most modern ‘Radiography’ DR systems use a Cesium Iodide [CsI] crystal fluorescent layer coated above an electron emissive layer of amorphous Silicon [a-Si] on a glass substrate

Image acquisition is a two stage process, x-ray conversion to light, followed by light conversion to electrons

The electrons are ‘trapped’ in the silicon semi-conductor until read-out as ‘charge packets’

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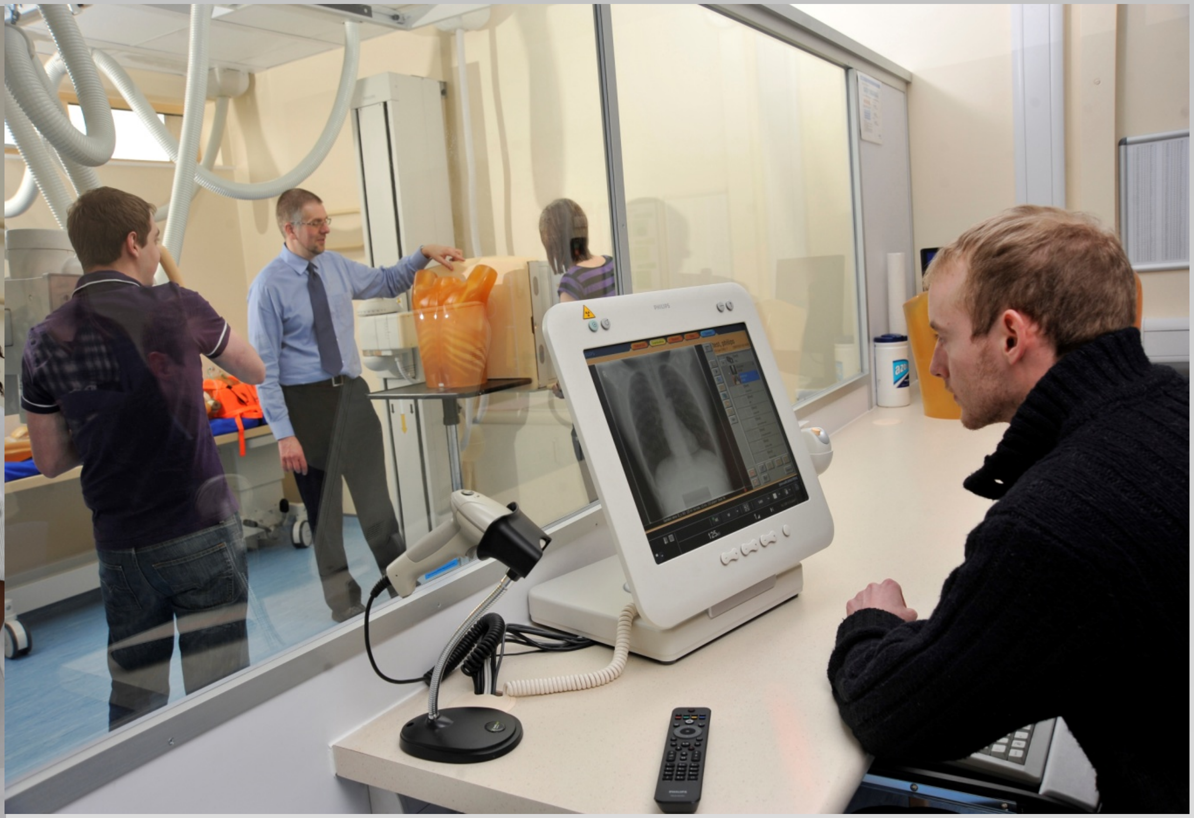

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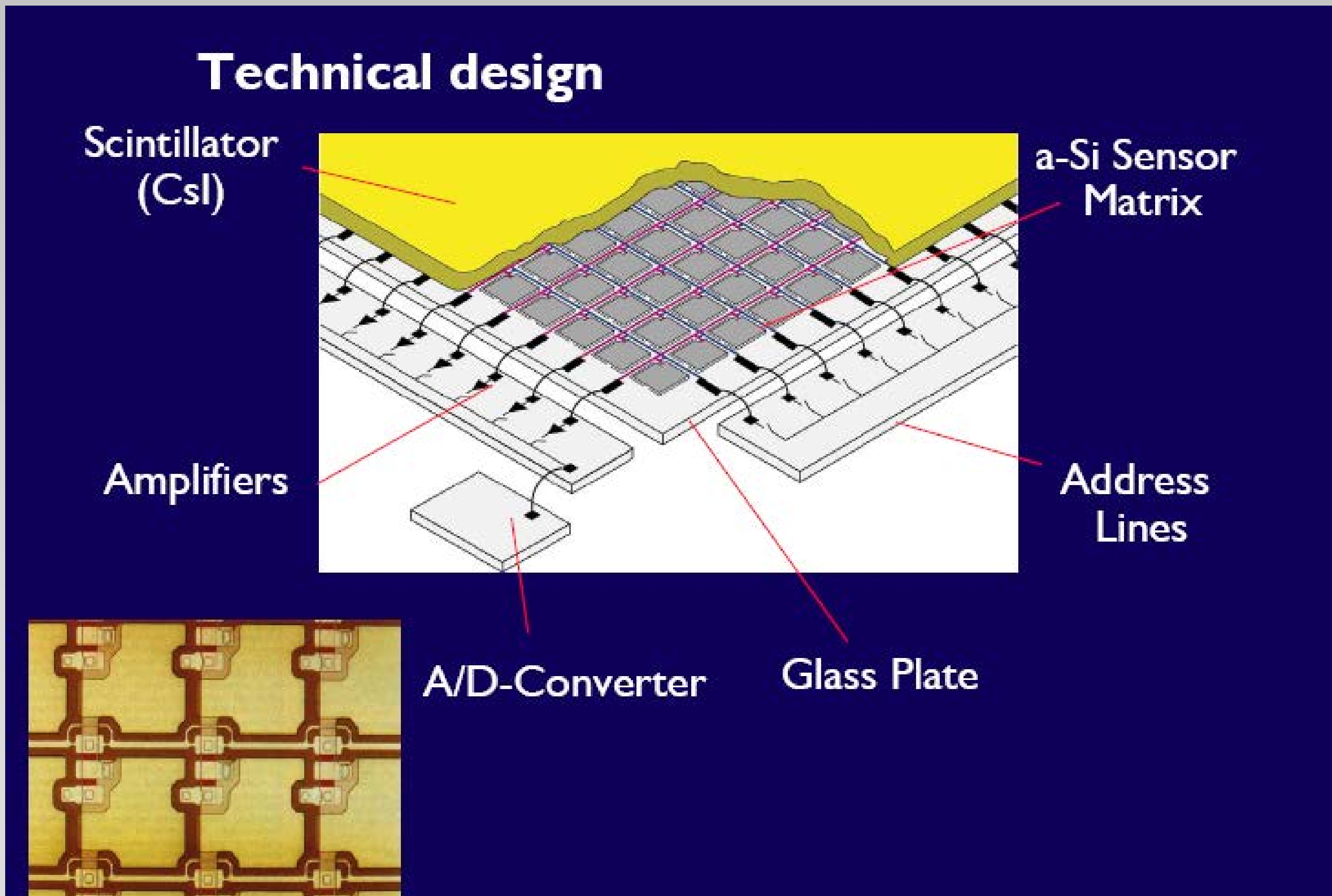

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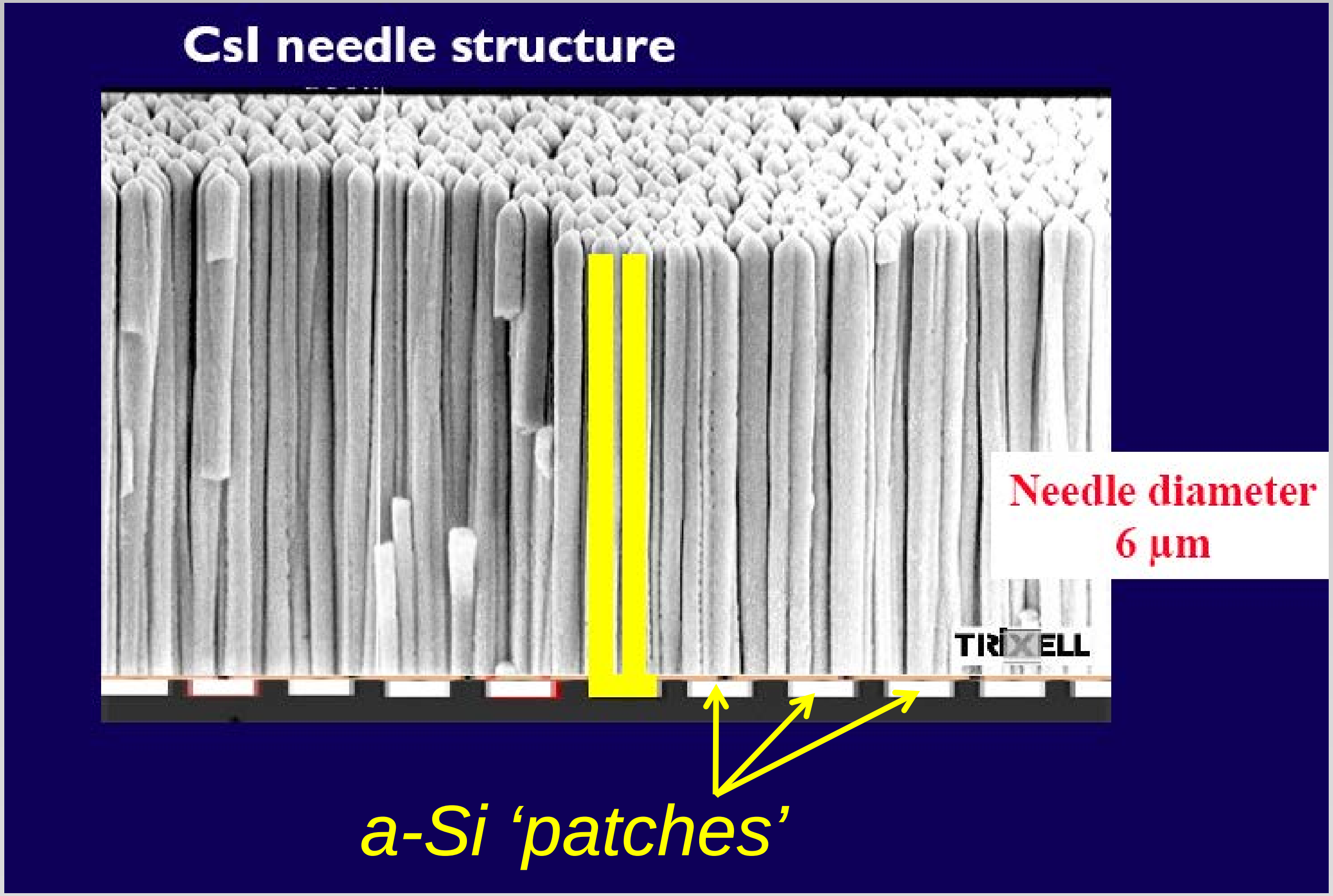
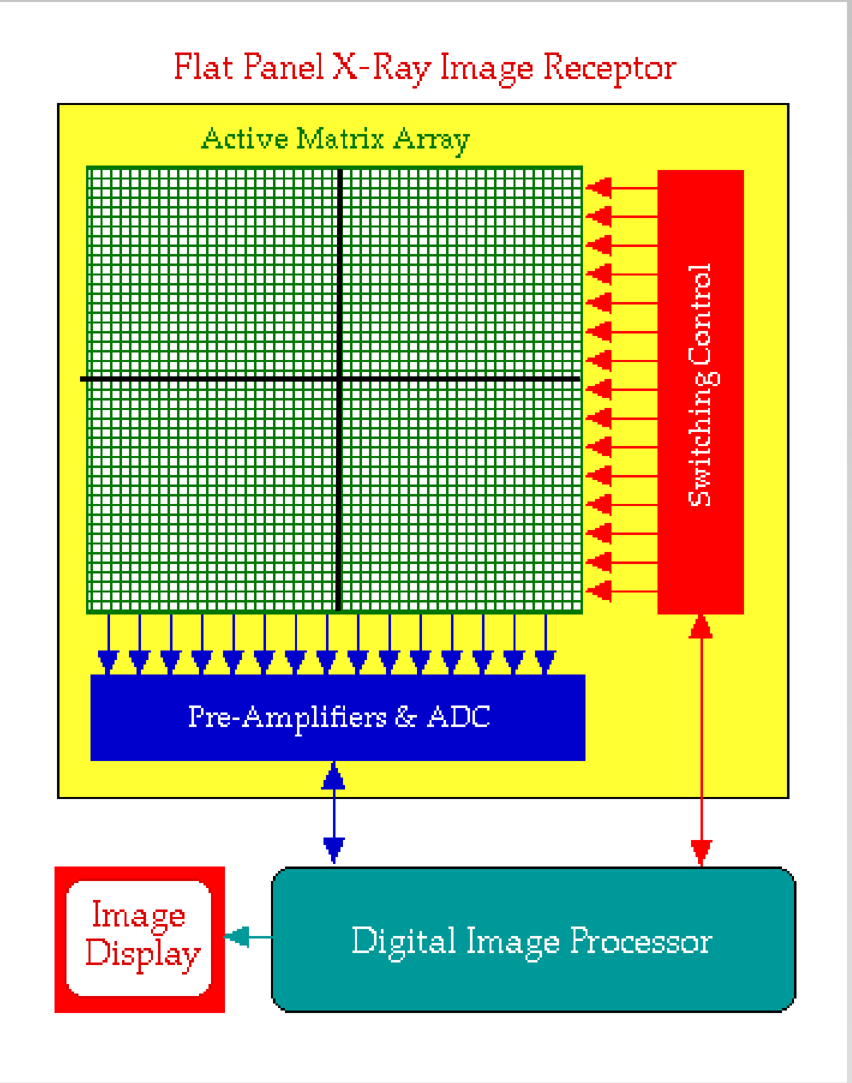


DR Imaging Technology –

The ‘active pixel array’ is of a ‘fixed’ size or matrix. The physical size of this active area can be up to 45 x 45 cms. With a typical matrix of around 9 Mega-pixels, the pixel pitch is around 125 microns or 0.125 mm^2

The active array is often ‘tiled’, into 4 quadrants to ease manufacturing problems.



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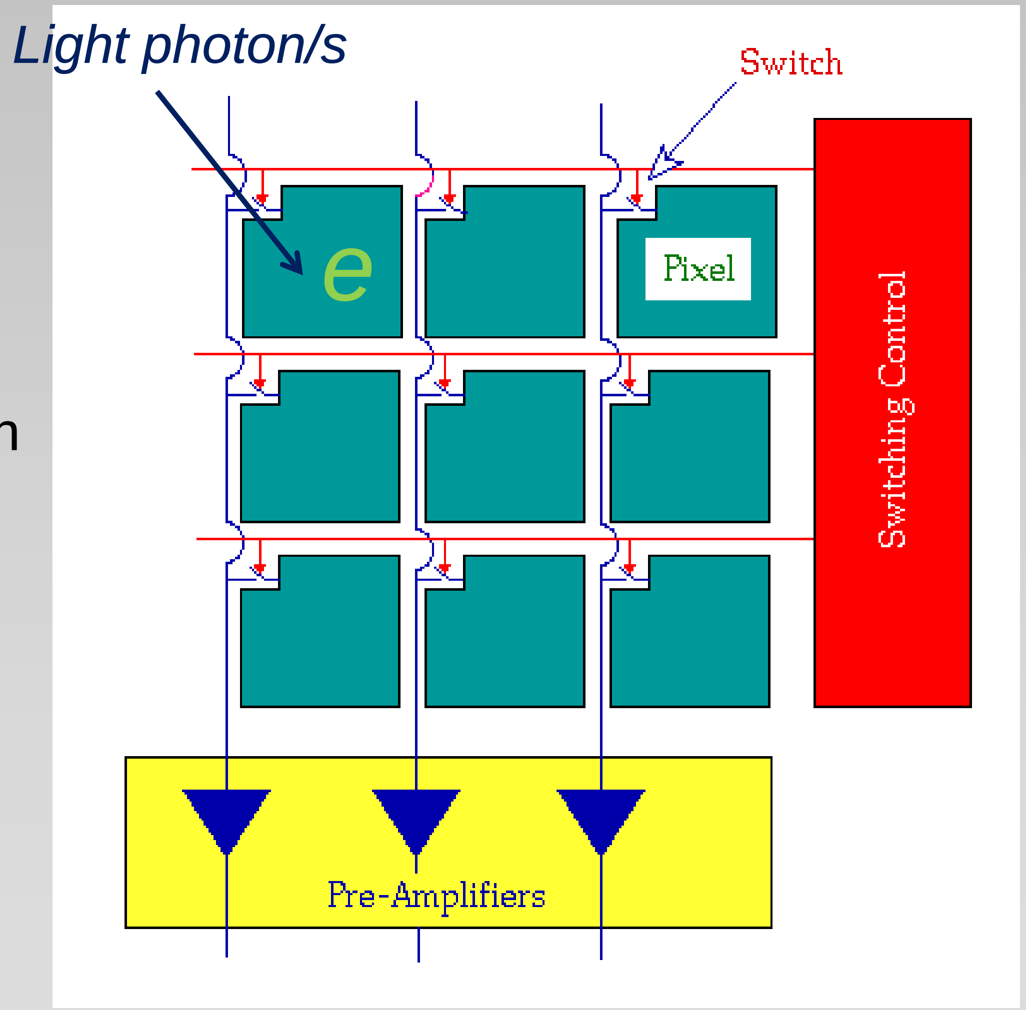
The ‘pixels’ are individually isolated within the a-Si ‘patches’ making them a ‘fixed’ size.

The active array switches are closed during the x-ray exposure to allow ‘charge’ to gather in each pixel patch.

Finally the switches are opened, column by column, and the charge packets read out and ‘quantised’ via an ADC [analogue to digital conveter]



CR & DR Comparisons

DETECTIVE QUANTUM EFFICIENCY

An expression of the efficiency of an imaging system's transfer, from its input to its output, as a percentage of signal to noise ratios (SNR).

DQE is the measure most representative of image quality in terms of an observer's ability to detect objects of interest in an image.

DQE has superseded reliance upon previous measurement criteria such as measuring MTF or resolution performance as a function of visible line pairs.

DQE = SNR^2 at detector output / SNR^2 at detector input

Measures transfer of both signal and noise.

DQE limited in practice to about 70%

CR & DR Comparisons

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	CR	DR
DQE	0.25 – 3.0	0.5 – 0.70
Spatial resolution	0.1mm – 0.17mm	0.125mm
Bit depth	12 bit	12 bit
Dynamic range	~	~
Cost effectiveness	high	???? life-span
Throughput	film-like 60s cycle	2-6s

Seeram E., [2009], "Digital Radiography; An Introduction", Delmar, Cengage Learning, NY, ISBN 1-4018-8999-9

This costs just £20 !

My advice is ;

1. ***Buy it,***

2. ***Read it ?***