

Archival Digital Image Quality, Storage and Migration Strategies

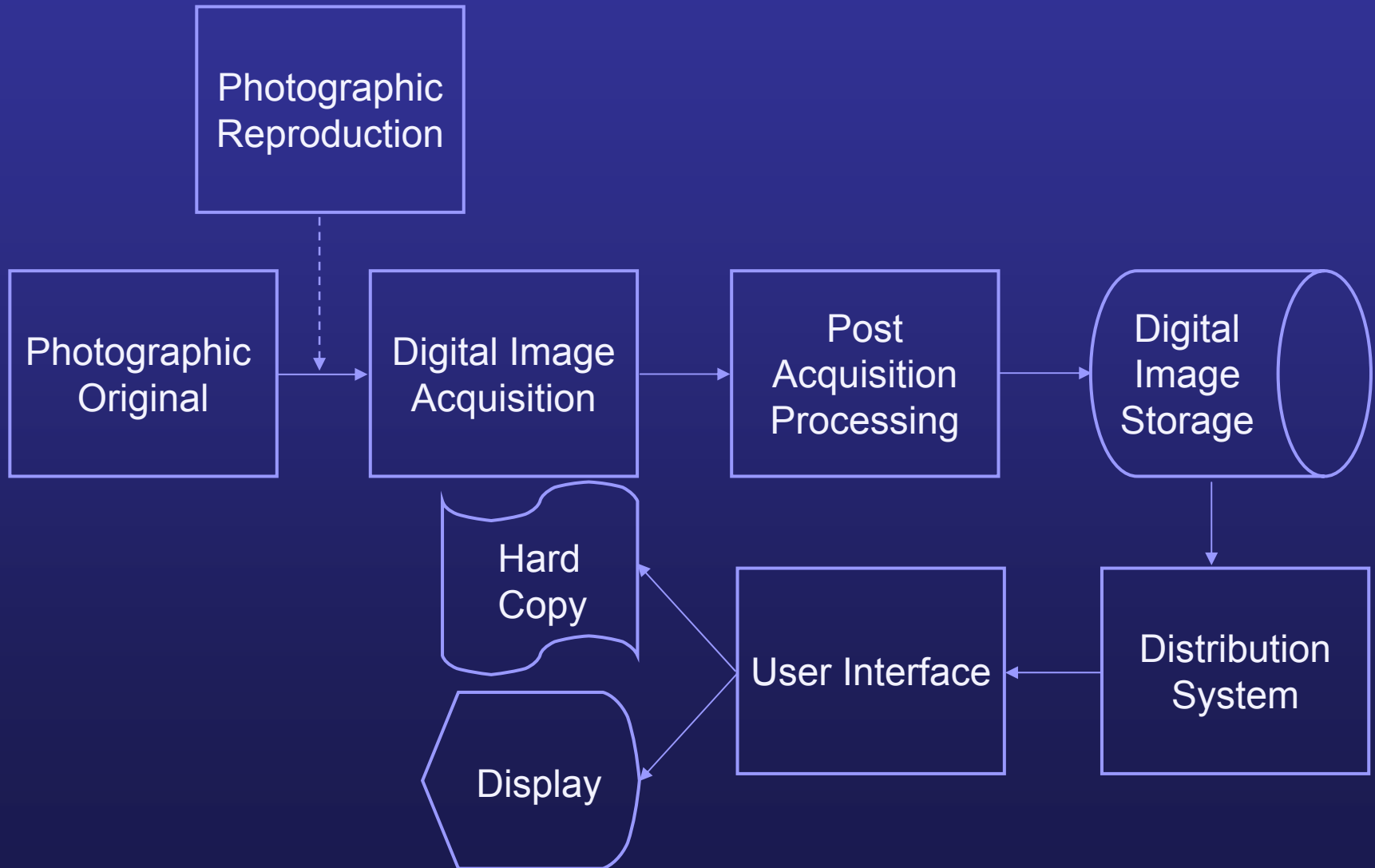
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Introduction – Aims

- Describe *the processes* involved in the digitisation of an image collection / archive.
- Provide guidelines on the quantification of *aspects of Image Quality* of the reproduction.
- Discuss digital image storage and migration strategies.

Steps Involved in Digitisation



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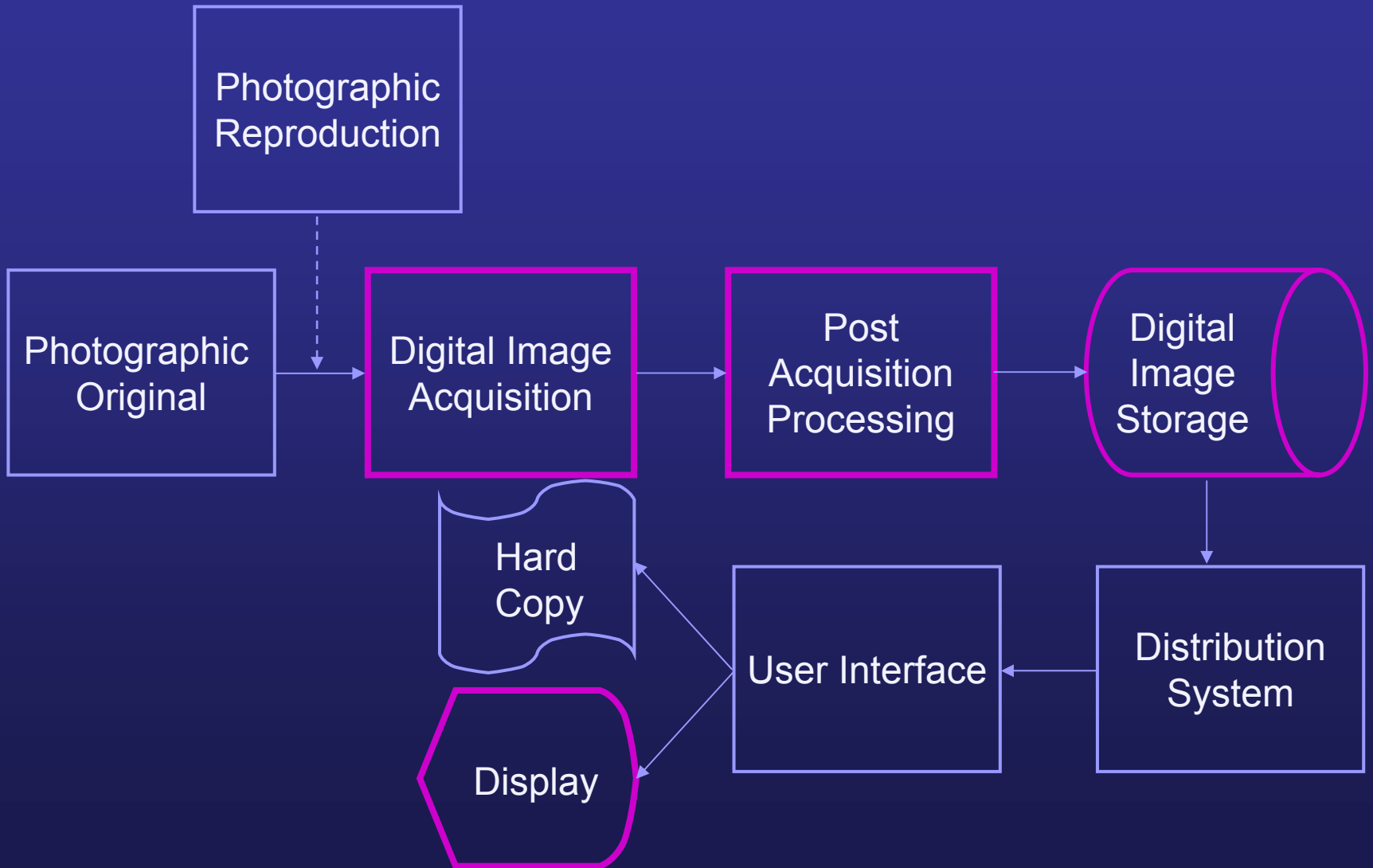


Image Quality - Attributes

Image Attribute

- *Tone*
- *Colour*
- *Resolution*
- *Sharpness*
- *Noise*
- *Digital Image Artefacts*

Visual Description

- Macroscopic contrast or *intensity reproduction*.
- Differences in *lightness*, *chrominance* and *saturation*.
- Discrimination of *fine detail*.
- Microscopic contrast or reproduction of *edges*.
- Spurious information.
- Blocking, contouring, ringing.....

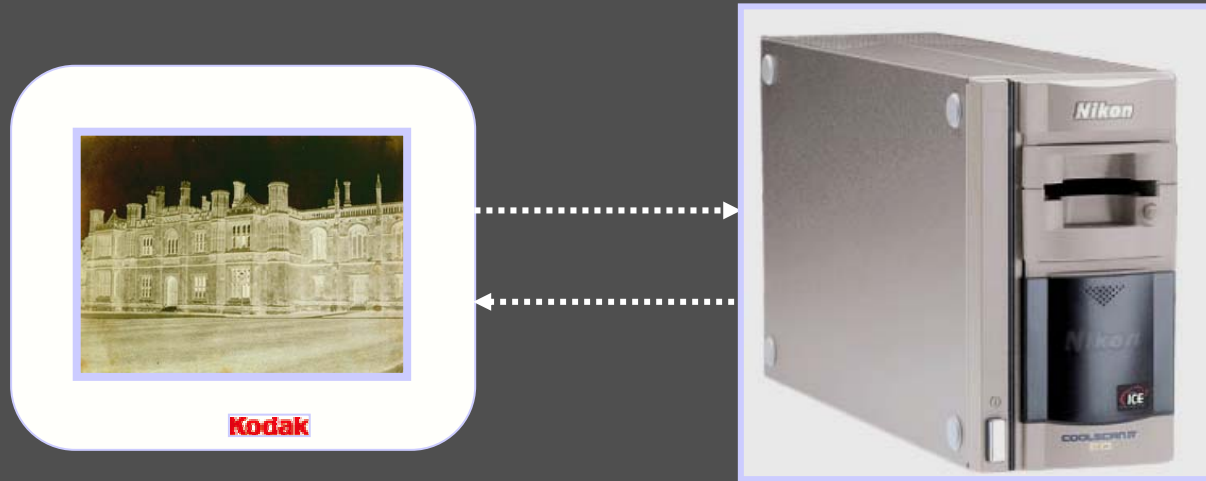
Digital Acquisition System

Attribute

Parameters affecting the attribute

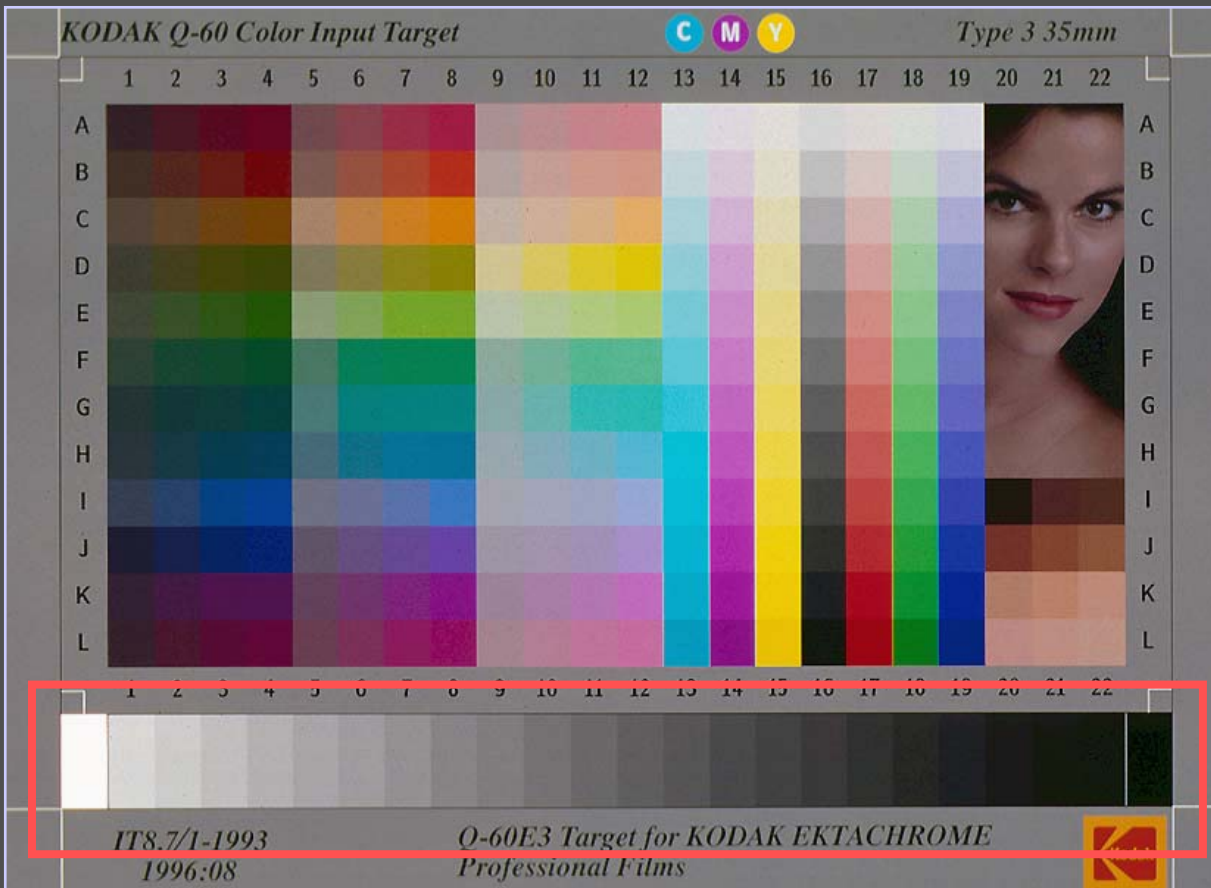
- *Tone*
Dynamic range, bit depth, transfer function, contrast (γ).
- *Colour*
Illumination, spectral sensitivity, colour filters, spectral transmittance (optics), photographic dyes (original).
- *Sharpness/Resolution*
Optics, sampling aperture, number of pixels, charge transfer efficiency, mechanical scan.
- *Noise*
Photo & detector noise, non-uniformities, dead pixels.
- *Artefacts*
Post-processing (ringing), compression (blocking, blurring), aliasing (sampling interval) contouring (bit-depth).

Digital Acquisition - Characterisation



- *Tone reproduction* (Transfer function)
- *Resolution & sharpness* (Modulation transfer function - MTF)
- *Colour reproduction* (Relate scanner RGB with visual tri-stimulus values)

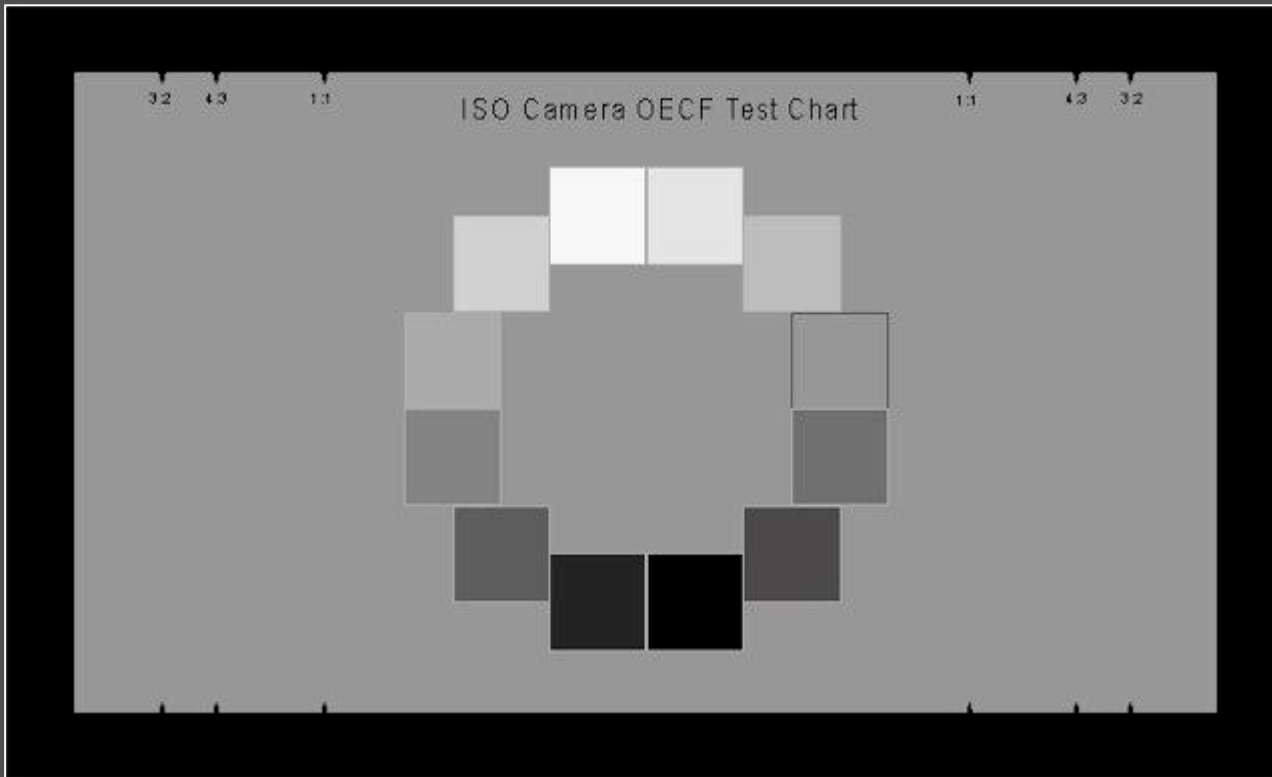
Digital Acquisition - Tone



*Optoelectronic
Conversion
Function
(OECF)*

ANSI IT8
Standard target

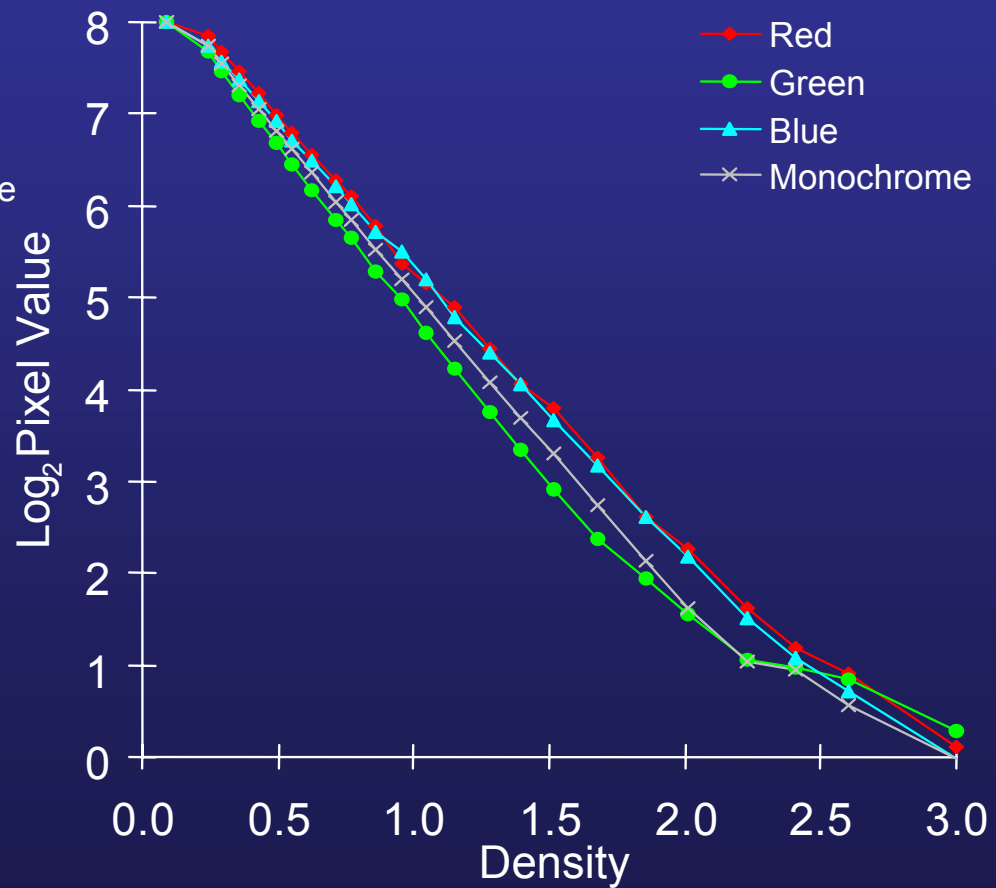
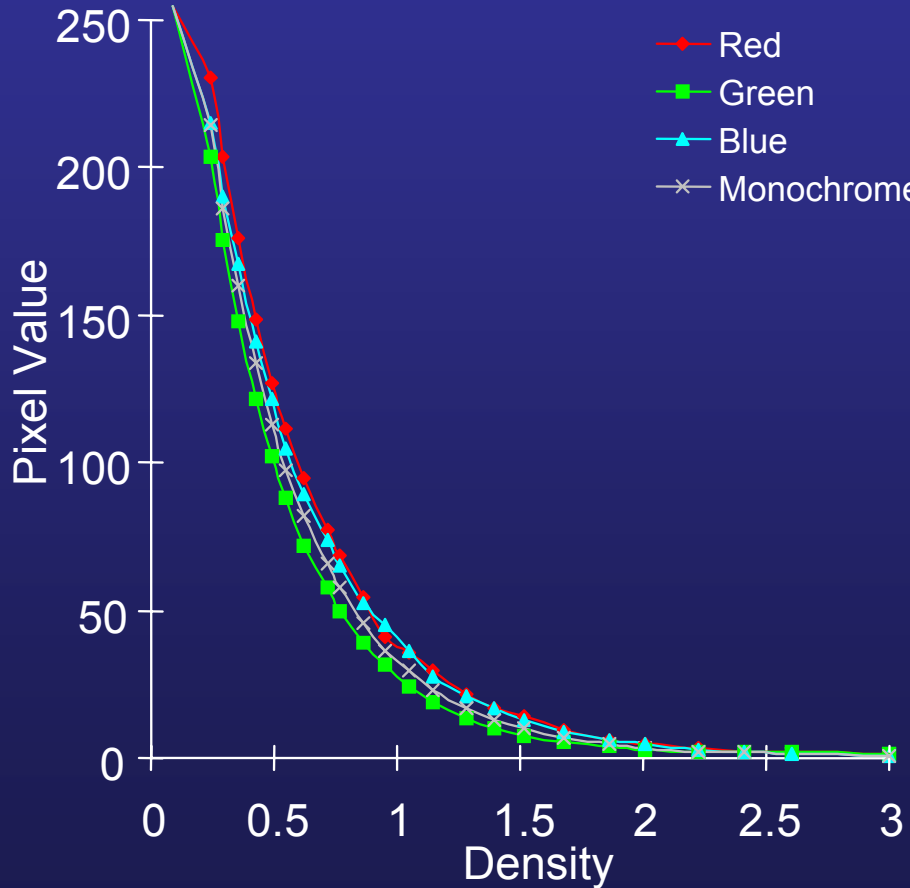
Digital Acquisition - Tone



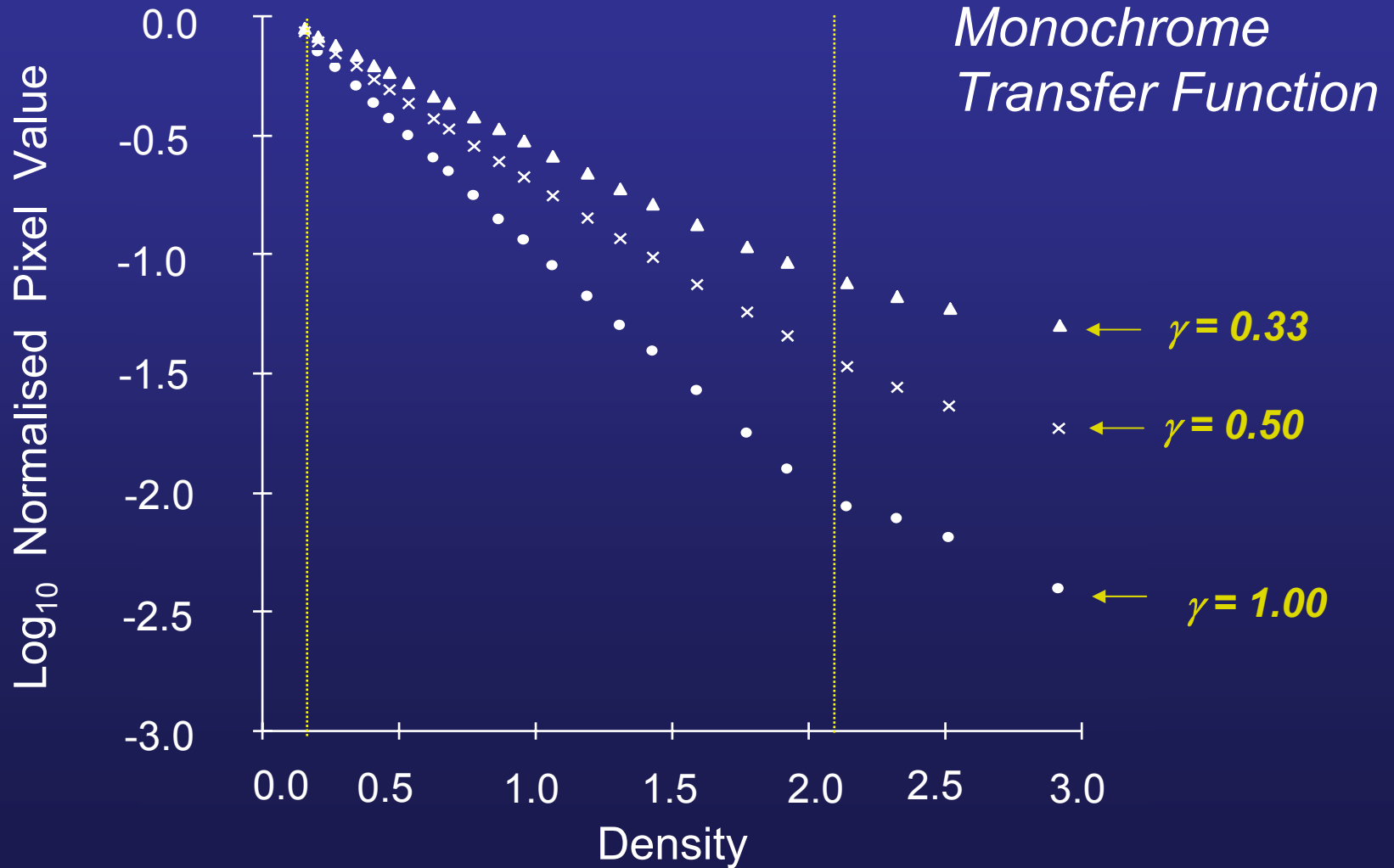
*Optoelectronic
Conversion
Function
(OECF)*

ISO 14524
Standard target

Digital Acquisition - Tone

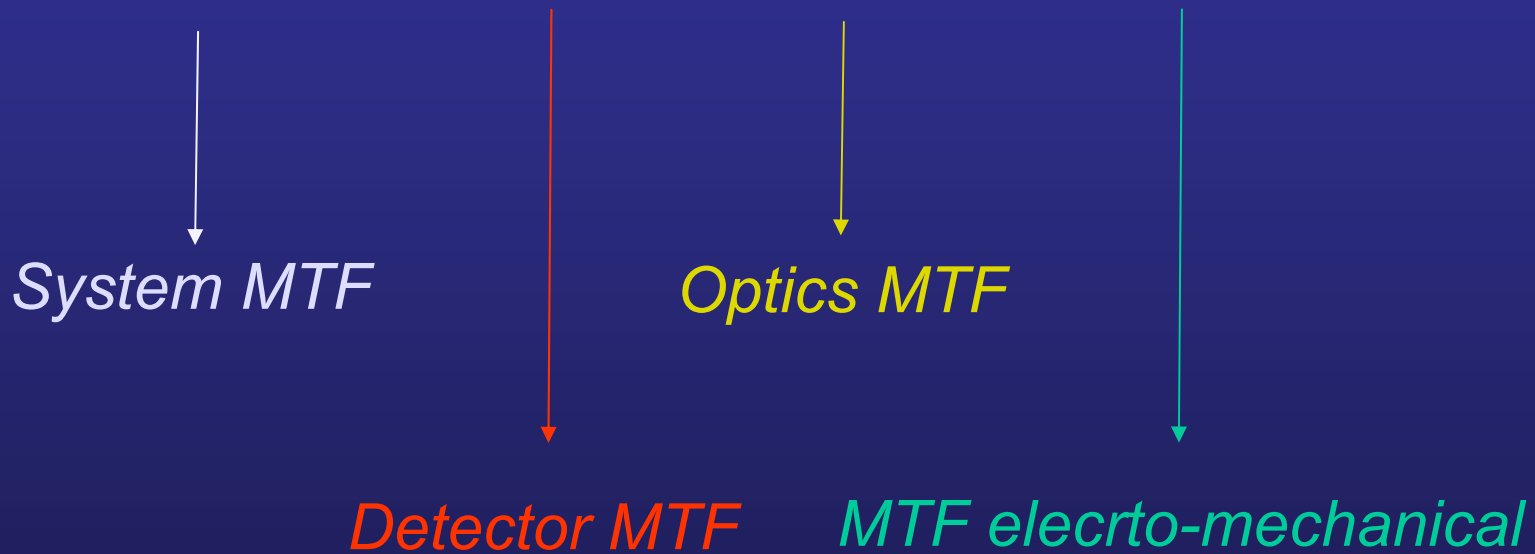


Digital Acquisition - Tone



Digital Acquisition - Sharpness

$$M(\omega) = M_d(\omega) M_o(\omega) M_{em}(\omega)$$

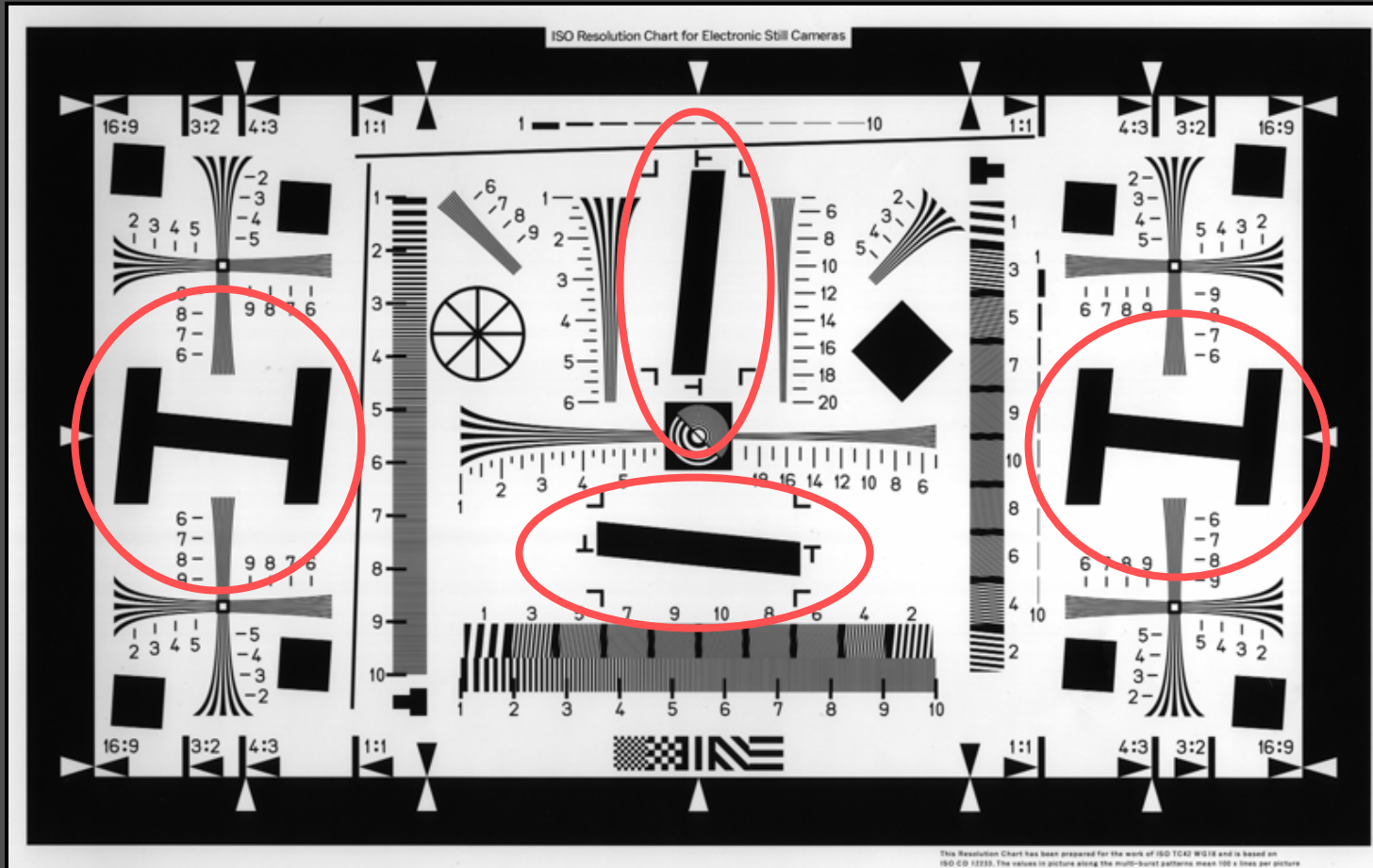


Digital Acquisition - Sharpness

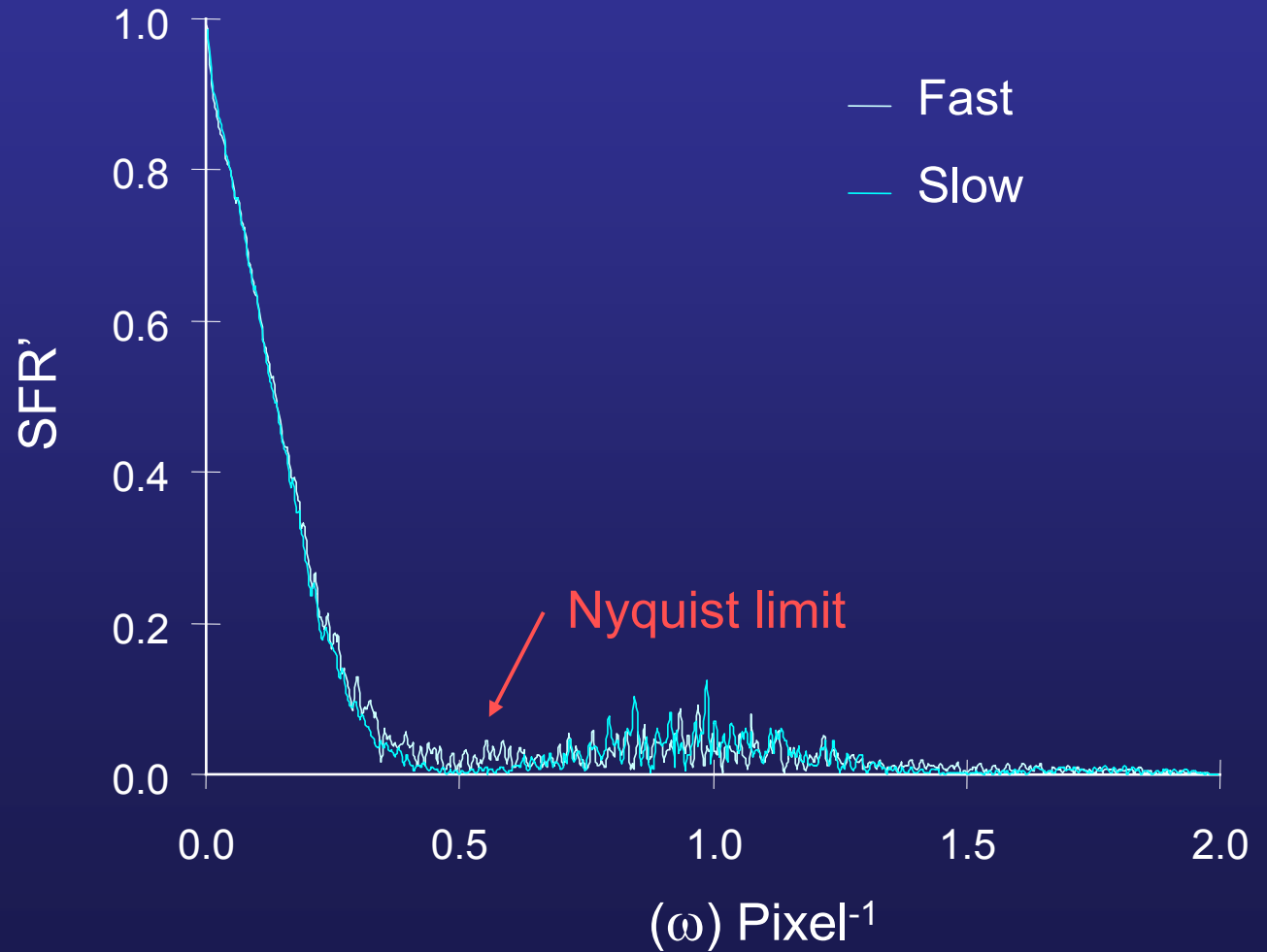
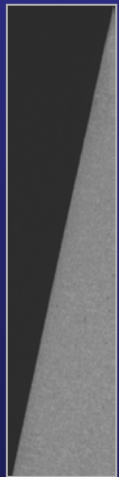
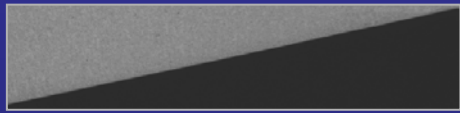
*ISO (12233, 16067-1, 16067-2)
Slanted Edge SFR Method*

$$*SFR'(\omega) = SFR_{system}(\omega) M_{target}(\omega)*$$

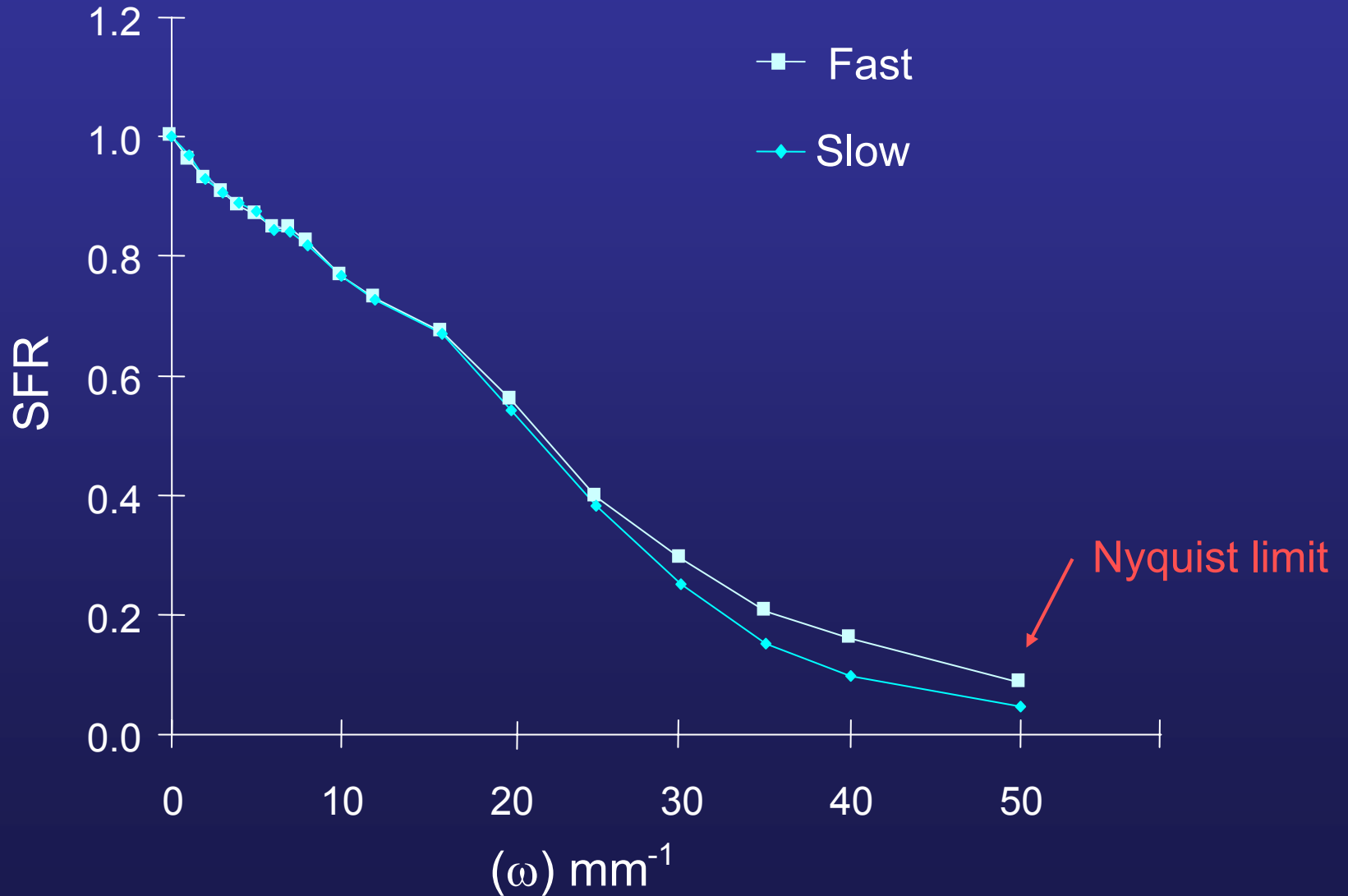
Digital Acquisition - Sharpness



Digital Acquisition - Sharpness



Digital Acquisition - Sharpness



Digital Acquisition – Colour

Polynomial Regression

- Grey Balance: neutral colours $R=G=B=f(Y)$
- Derivation of a $3 \times m$ colour-correction matrix

Digital Acquisition – Colour

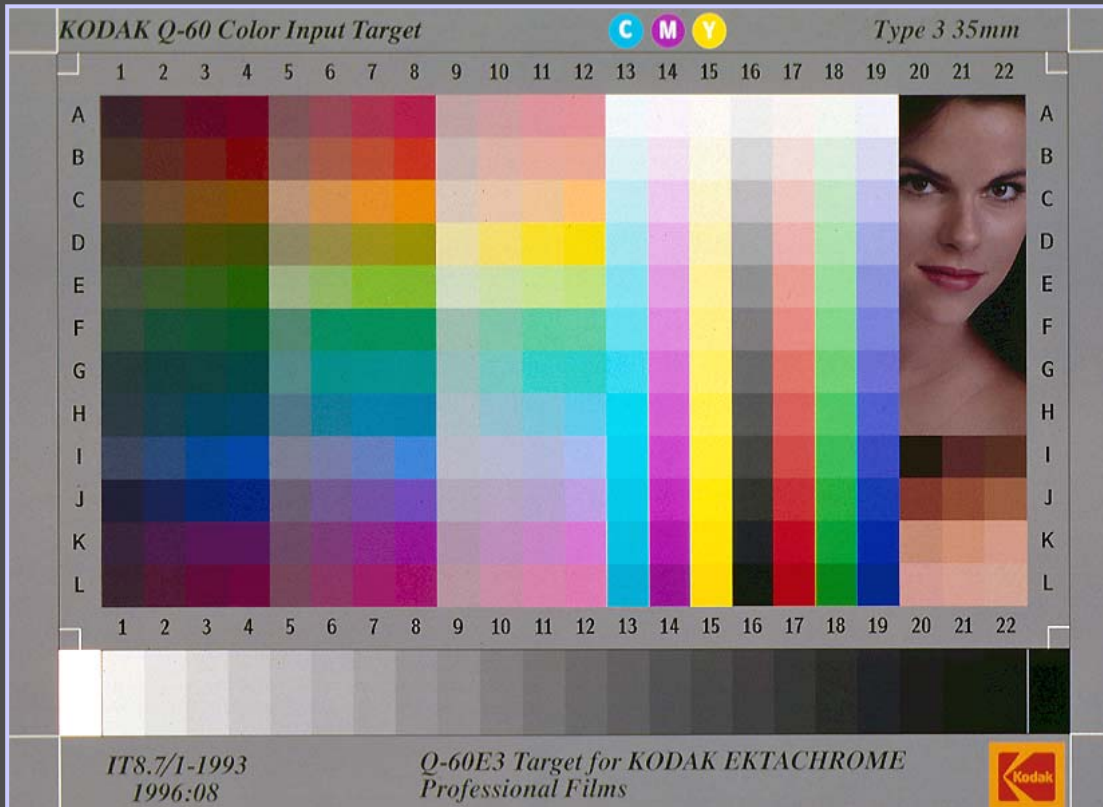
$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} a_{X1} & a_{X2} & a_{X3} & a_{X4} & a_{X5} & a_{X6} \\ a_{Y1} & a_{Y2} & a_{Y3} & a_{Y4} & a_{Y5} & a_{Y6} \\ a_{Z1} & a_{Z2} & a_{Z3} & a_{Z4} & a_{Z5} & a_{Z6} \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

R
G
B
RG
GB
RB

Digital Acquisition – Colour

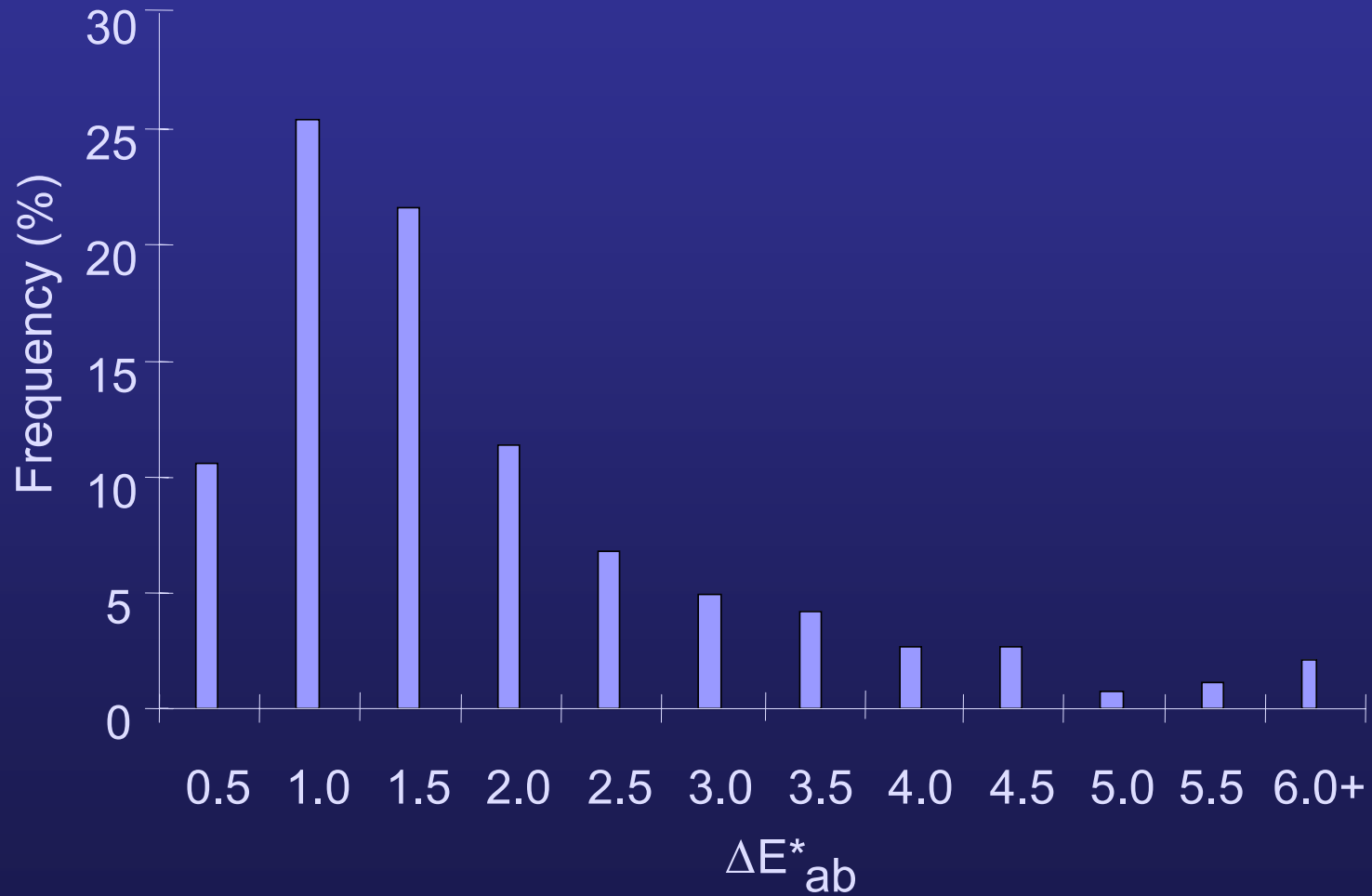
$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} a_{X1} & a_{X2} & a_{X3} & a_{X4} & a_{X5} & a_{X6} \\ a_{Y1} & a_{Y2} & a_{Y3} & a_{Y4} & a_{Y5} & a_{Y6} \\ a_{Z1} & a_{Z2} & a_{Z3} & a_{Z4} & a_{Z5} & a_{Z6} \end{pmatrix} \begin{pmatrix} R \\ G \\ B \\ RG \\ GB \\ RB \end{pmatrix}$$

Digital Acquisition – Colour

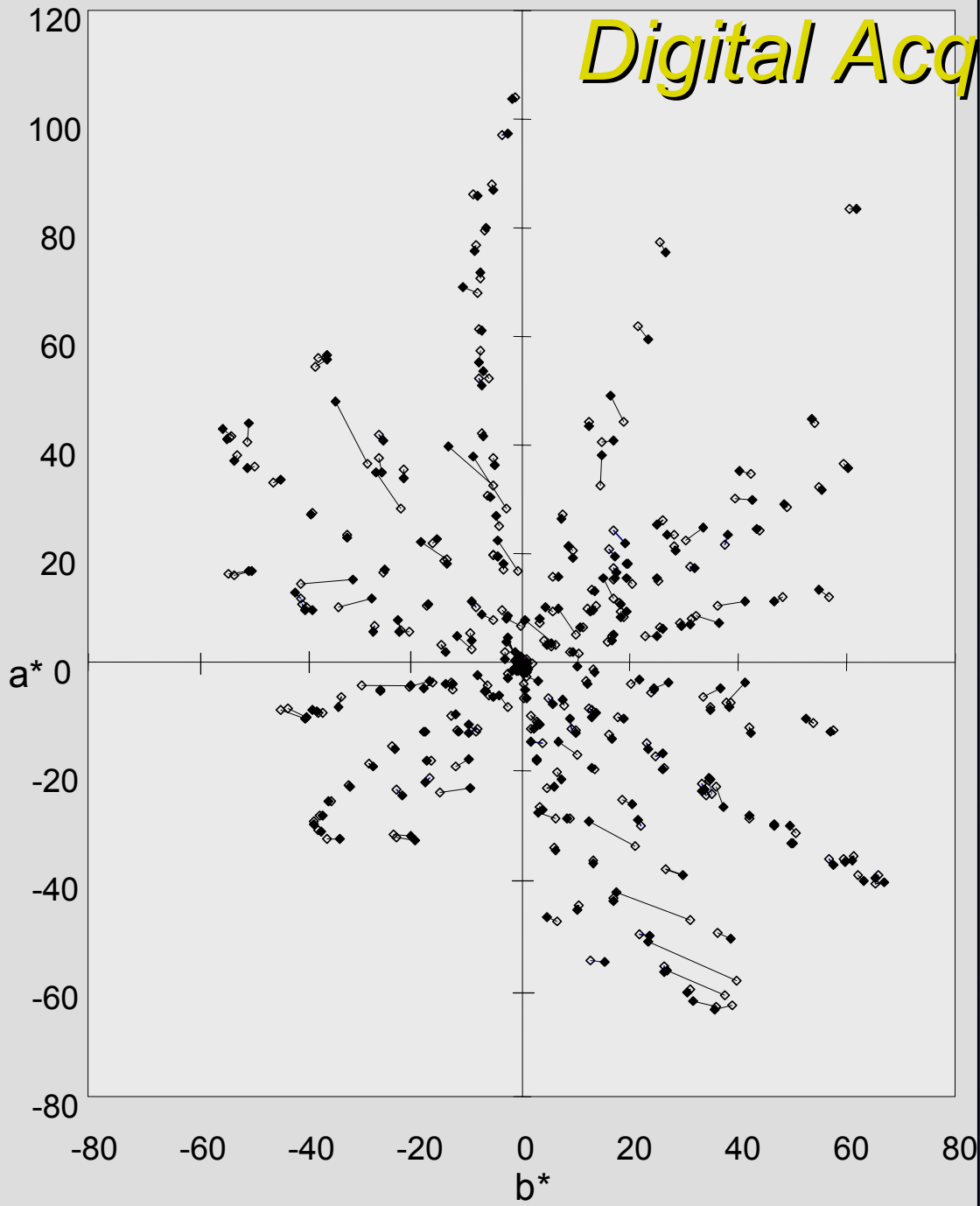


- ANSI IT8 on Kodak Ektachrome slide film.
- CIE D_{65}
- CIE 1931 2°

Digital Acquisition – Colour



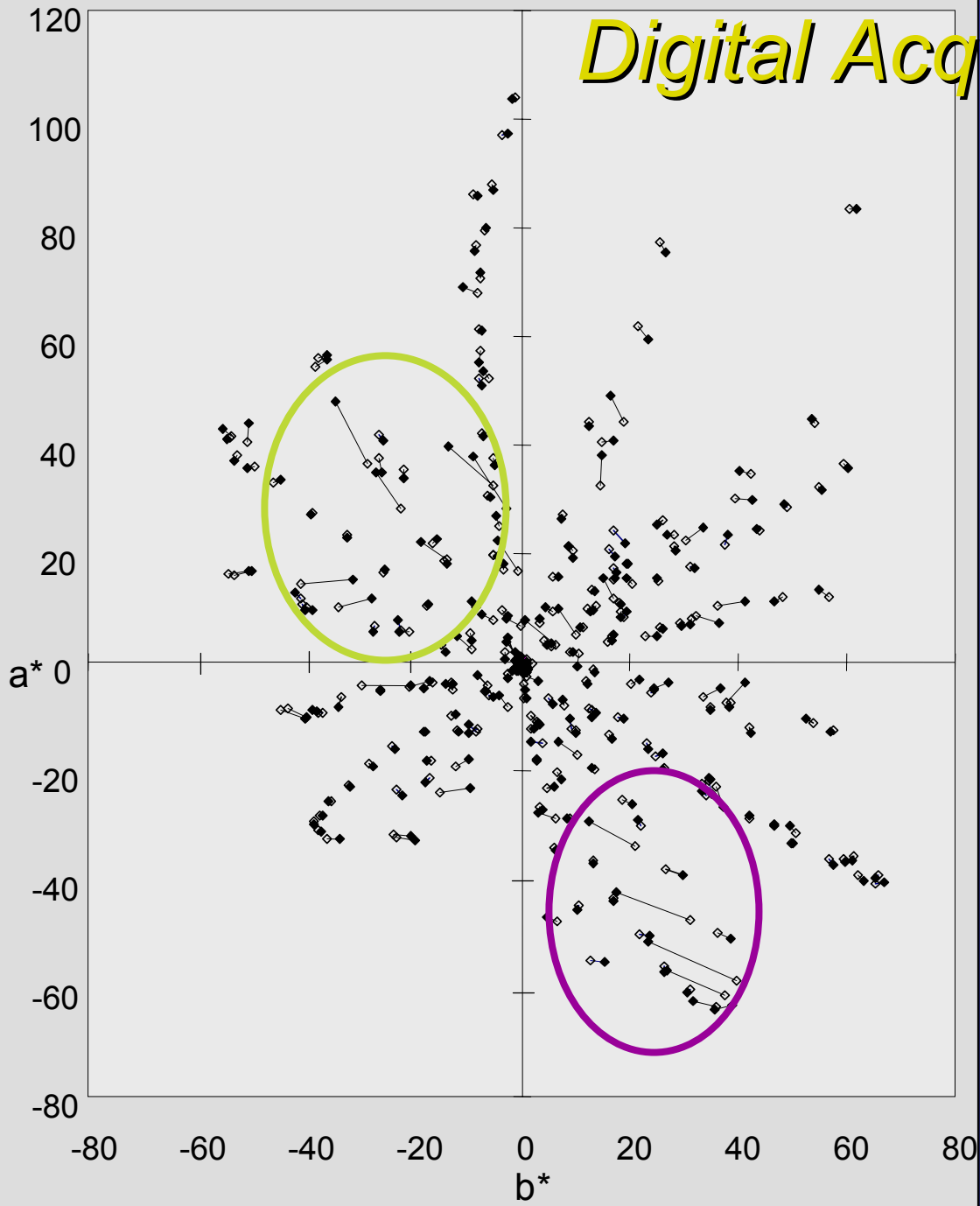
Digital Acquisition – Colour



Larger mismatches:

- yellow-green
- violet
- outer regions

Digital Acquisition – Colour



Larger mismatches:

- yellow-green
- violet
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Post Acquisition – Image Encoding



- *Convert from scanner tri-stimulus to an output colour space*
 - Such as sRGB colour space, Adobe RGB or other.
- *Assess output space (sRGB)* - Losses in the available range of colours.

Post Acquisition – Image Encoding

sRGB

Reference Display (CRT)

- Luminance Level : 80 cd/m²
- White Point : CIE D₆₅
- Model offset (R,G,B) : 0.055
- Model gamma (R,G,B) : 2.4

Post Acquisition – Image Encoding

sRGB

Reference Viewing Conditions

- Ambient illuminance level : 64 lux
- Ambient white point : CIE D_{50}
- Veiling glare : 1.0%

- Reference observer : CIE 1931 2°

Post Acquisition – Image Encoding

sRGB

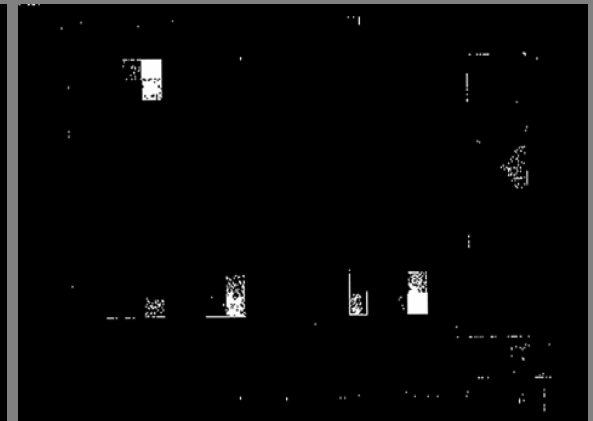
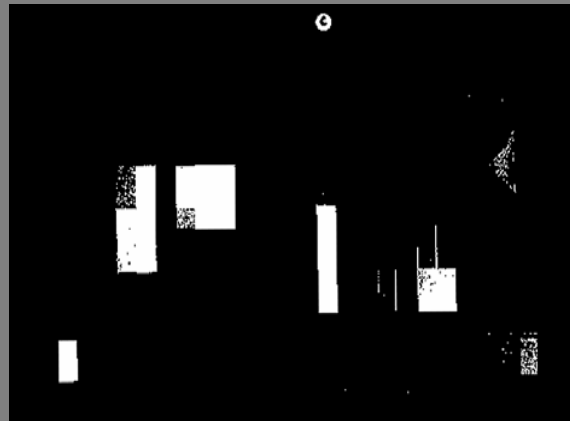
Encoding (transformation)

- Linear transformation from CIEXYZ to linear normalised display RGB.
- Application of a power function to compensate for the reference display transfer function.

Post Acquisition – Image Encoding

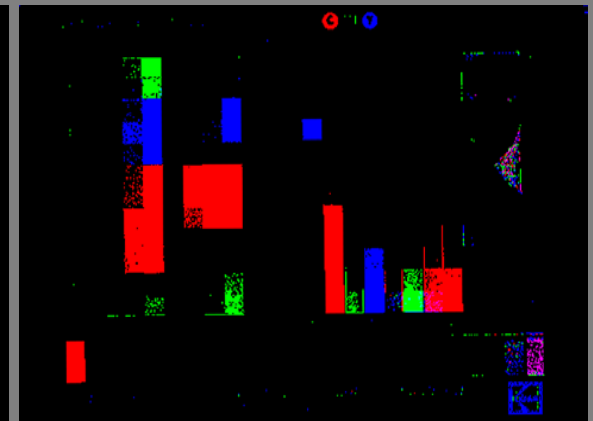
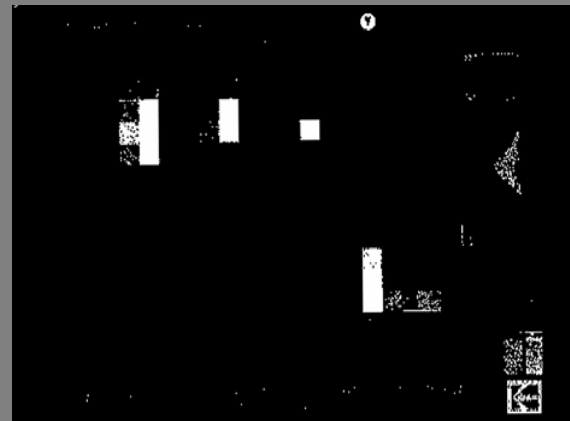
Red - 5.0%

Green - 1.4%

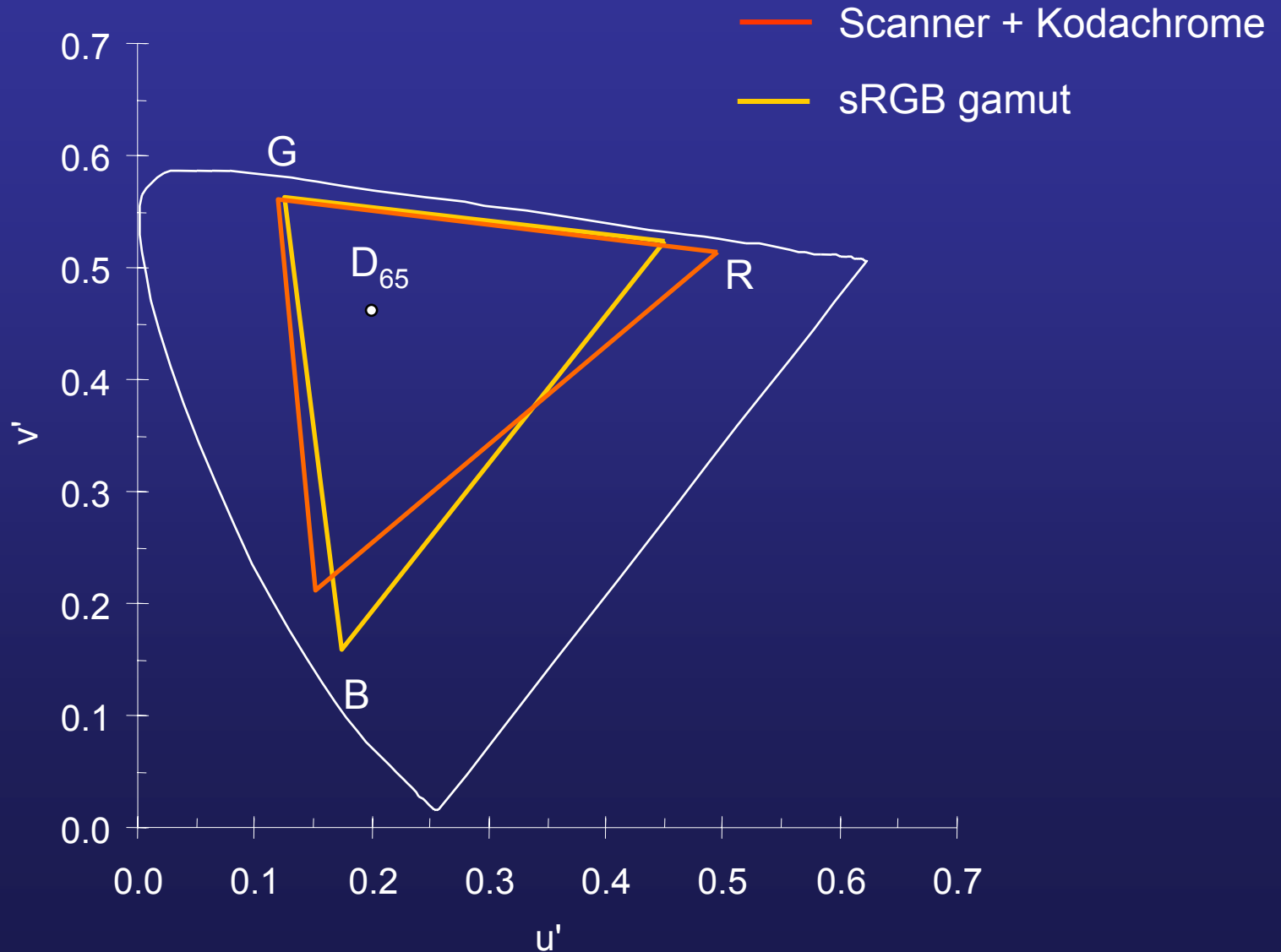


Blue - 2.5%

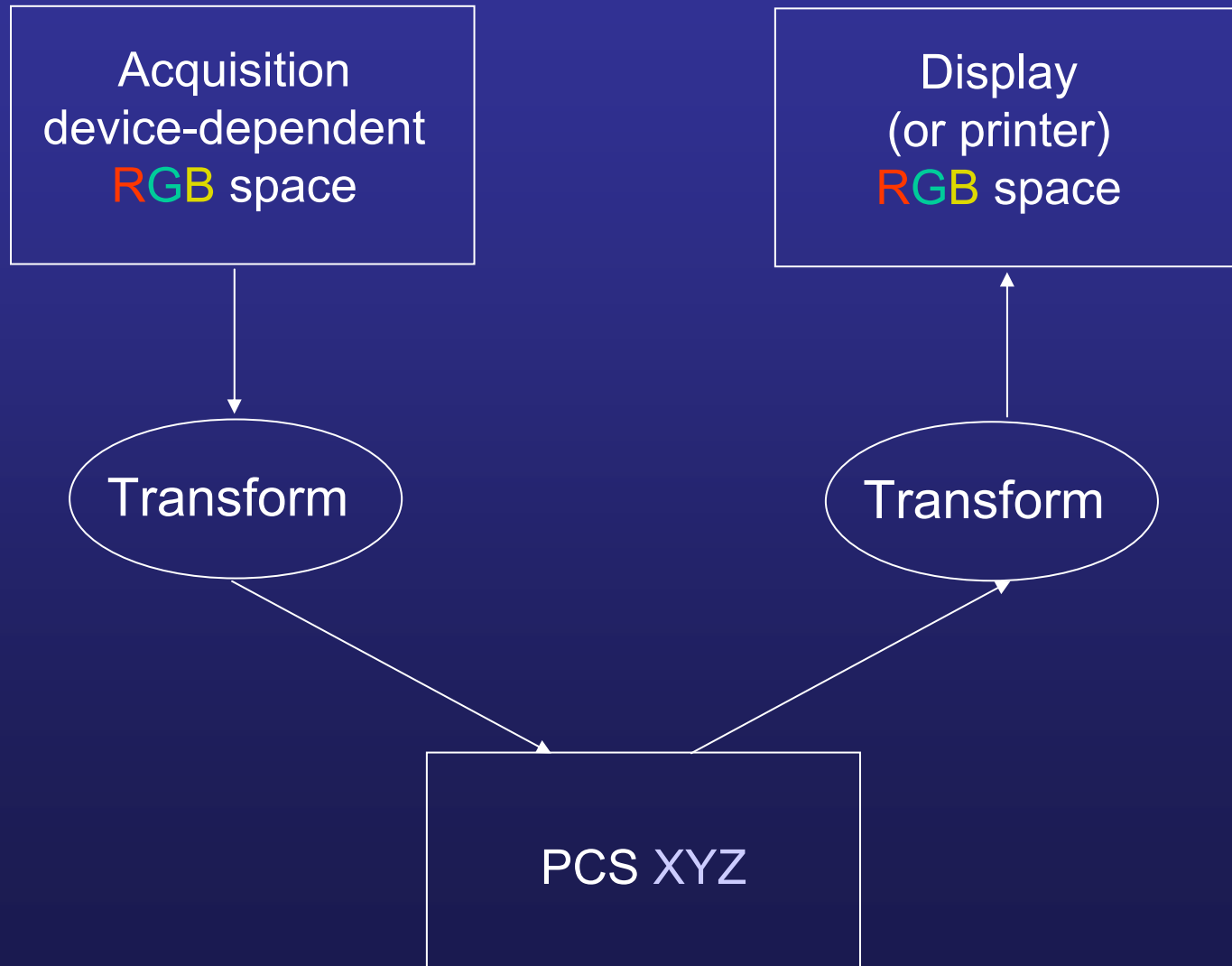
RGB



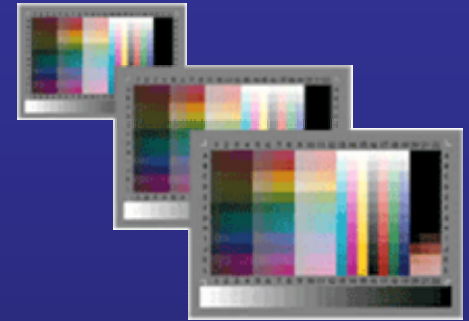
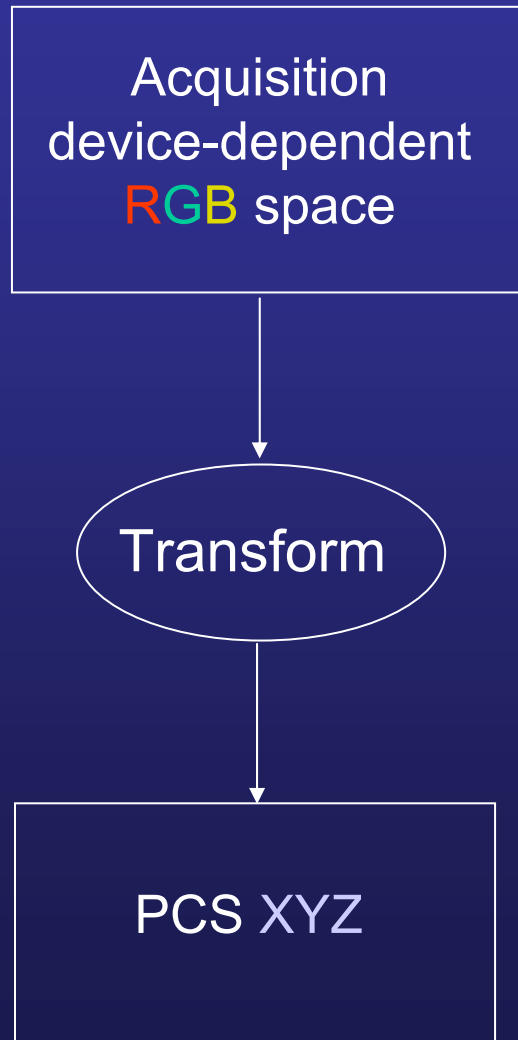
Post Acquisition – Image Encoding



Colour Management

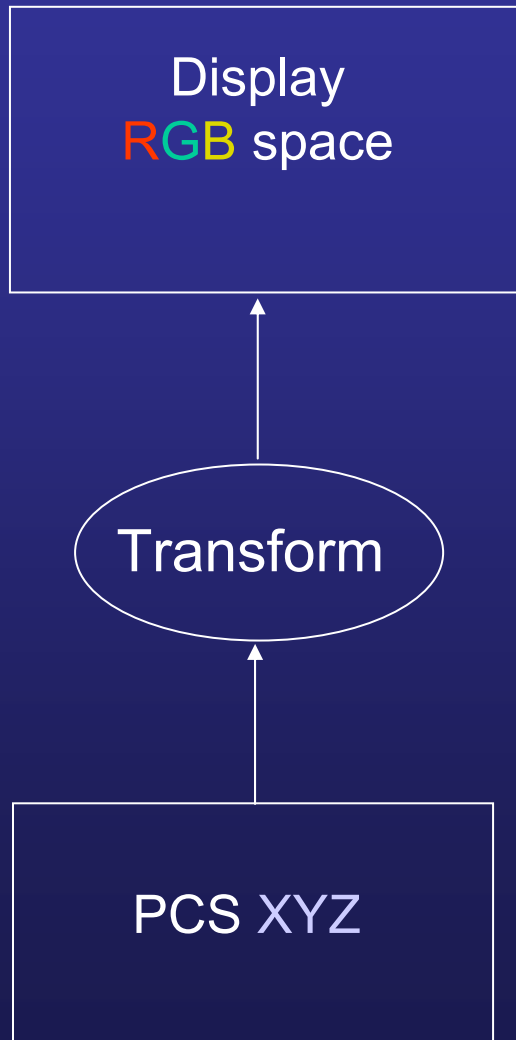


Colour Management – Acquisition Profile



- Measuring tool (spectrophotometer)
- **Profile** maker software
- Acquisition device **profile** must be attached to the acquired images.

Colour Management – Display Profile



- Colorimeter.



- Software for display characterisation.
- Display colour *profile*.

Colour Management

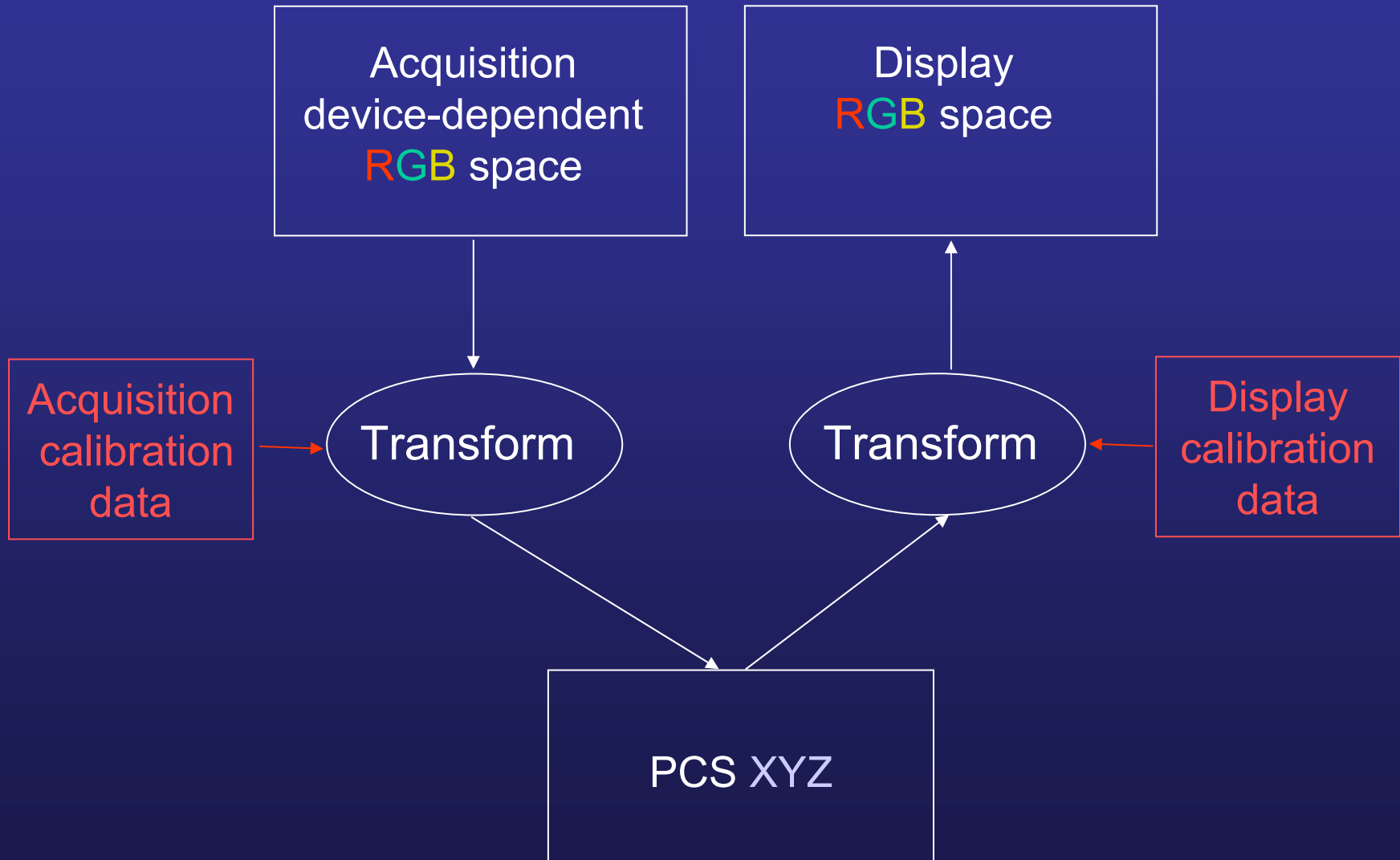


Image Storage – File Format



Tagged File Format (TIFF)

- Easy access and retrieval
- Thoroughly documented
- Source code available
- Fully supported by current H/S
- Expanded around a basic frame
- Most advisable for image archiving
- Colour profiles can be incorporated

Image Storage – File Format



JPEG 2000 (wavelet based compression scheme)

- Allows for lossless compression
- Allows for ROI compression
- Image stored at different resolutions
- Not fully supported by H/S
- Lossy IQ not fully evaluated

Image Storage – Medium



*Writable Compact Disks (CD-R),
ISO 9660*

- Fast random access
- Medium data capacity (~700 MB)
- Long physical lifetime
- Removable media
- Easily duplicated
- Write-once (R not RW)
- Cheap
- Industry and ISO standard

Image Storage – Medium



Digital Versatile Disk - DVD-ROM

- Obvious successor or CD-ROM
- Same physical size (120mm)
- Increased data capacity, up to 4.7 GB
- ISO standard format

Data Migration

Transfer from obsolete to newer systems

Hardware

- Storage medium - CD-R, DVD
- Reader - CD-DVD Drive
- Computer system

Software

- File Format
- Software driving the reader (driver)
- Operating system

Summary

- The digital image acquisition – most important step.
- Characterisation of acquisition device – if possible – is essential.
- Image Metadata should *ideally* be stored/preserved with the digital images.
- Digital image data should be acquired at the optical resolution of the scanner and be saved/stored in the scanner RGB colour space.
- Images can be then converted to appropriate colour space for any output (display or print).

Summary

- Colour management system:
 - acquisition device must be characterised / calibrated
 - input profile must be attached to digital image files
 - output device must be calibrated & profiled for specific viewing conditions.
- File format – TIFF
- Medium - CD-R (write once) – use ISO 9660 recording
- Migration of digital info is *essential*.