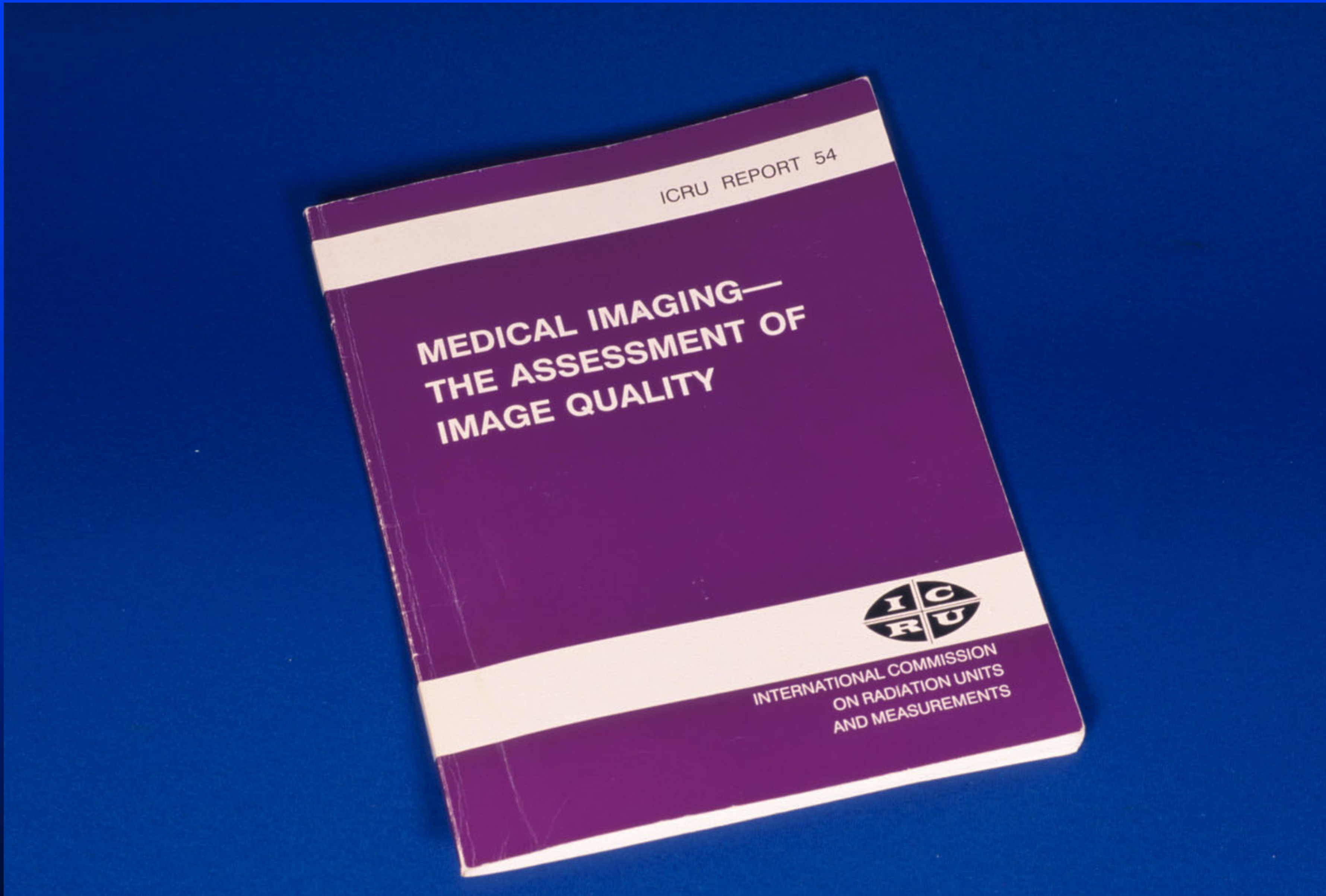
2012 :15th SESSION of ESMP

Lecture presented in Archamps (Salève Building) by :

Peter SHARP (Aberdeen)

IMAGE QUALITY THEORY

Peter F Sharp
University of Aberdeen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MEDICAL IMAGING—
THE ASSESSMENT OF
IMAGE QUALITY
ICRU
INTERNATIONAL COMMISSION
ON RADIATION UNITS
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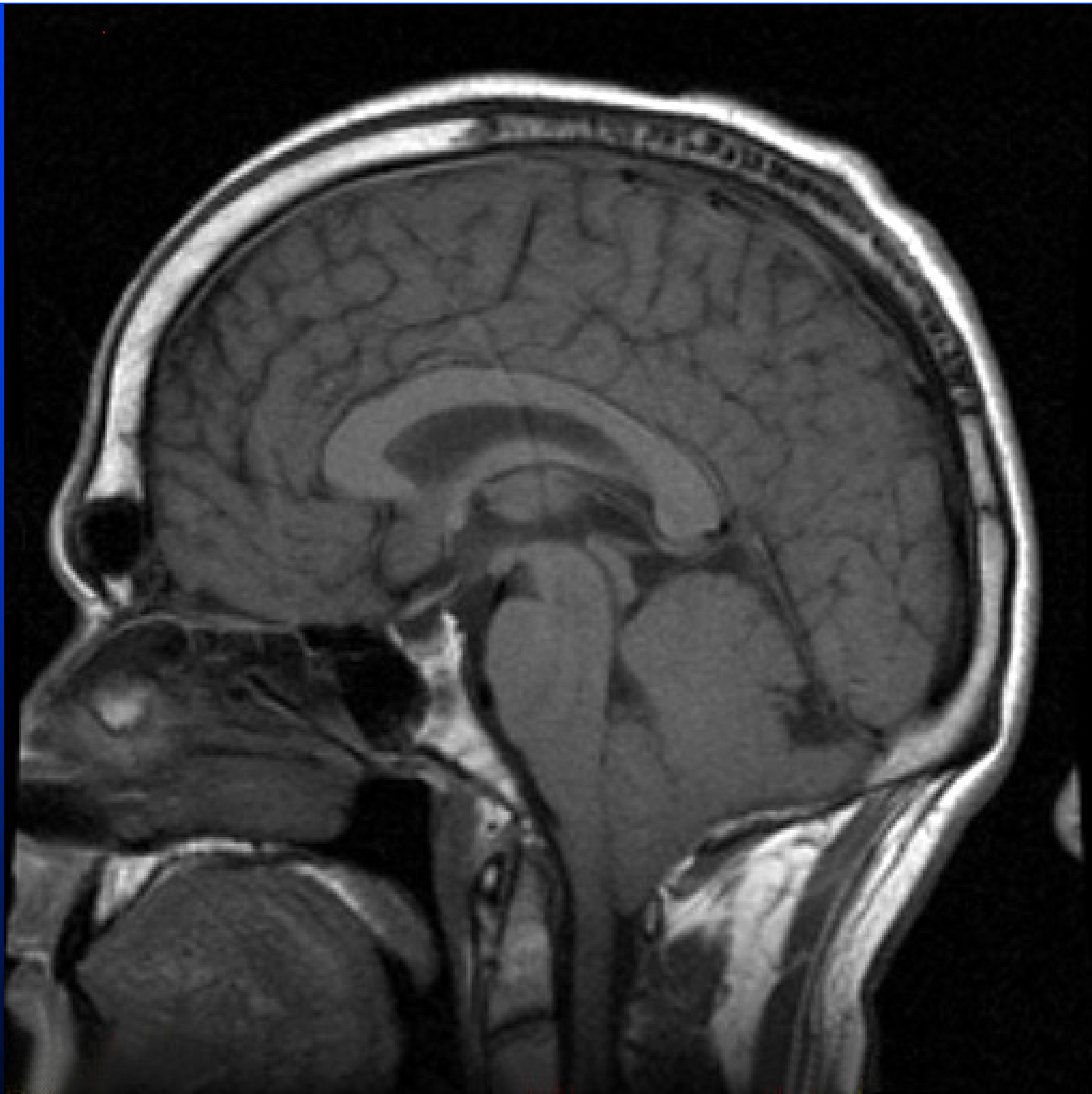
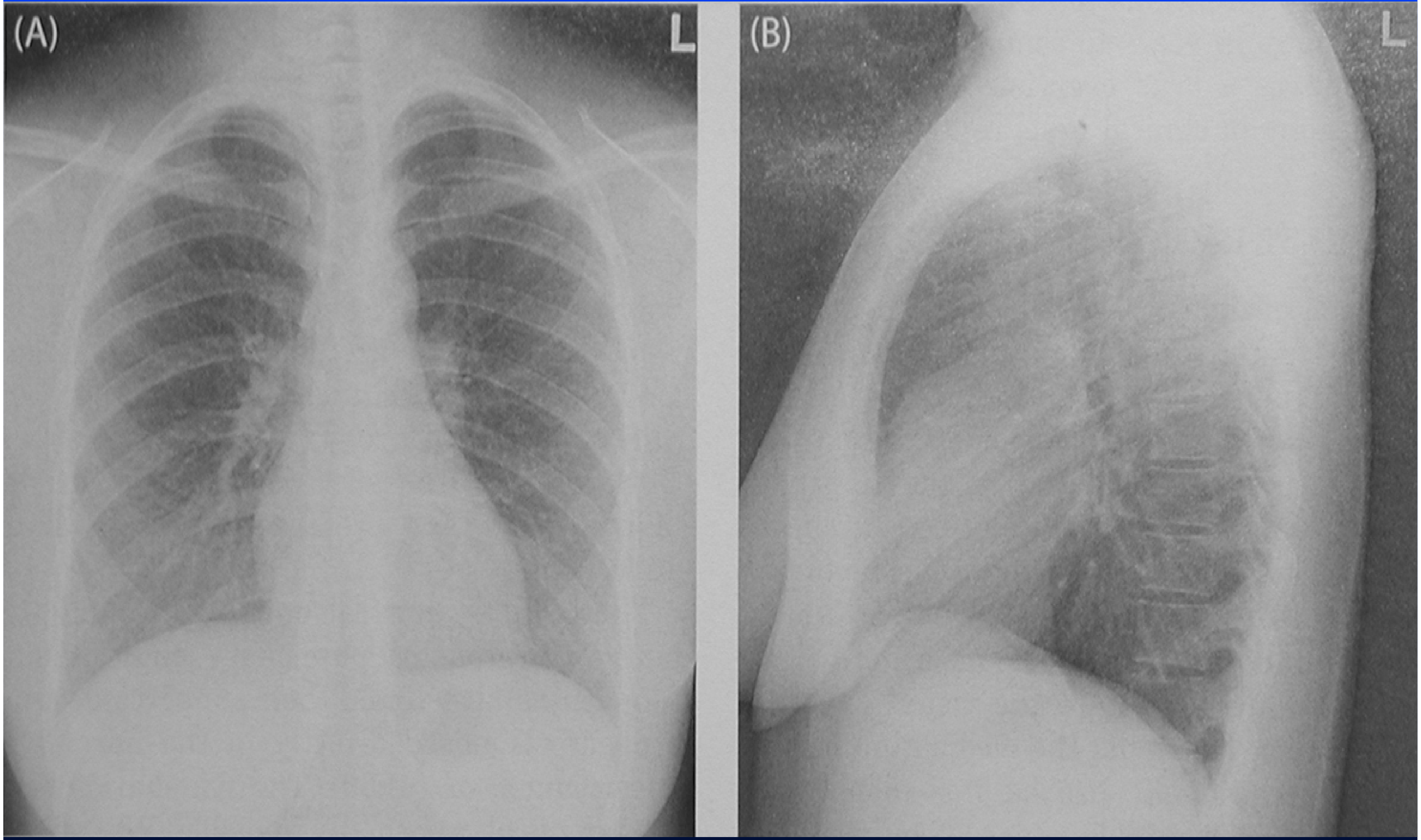
MEASUREMENTS

IMAGE QUALITY IS :

A MEASURE OF THE EFFECTIVENESS WITH WHICH AN IMAGE CAN BE USED FOR ITS INTENDED TASK.




(A)
L
(B)
L


ATL

MEASURING IMAGE QUALITY IS A TWO STAGE PROCESS:

- DEFINE THE TASK

- MEASURE THE ABILITY TO PERFORM THE TASK

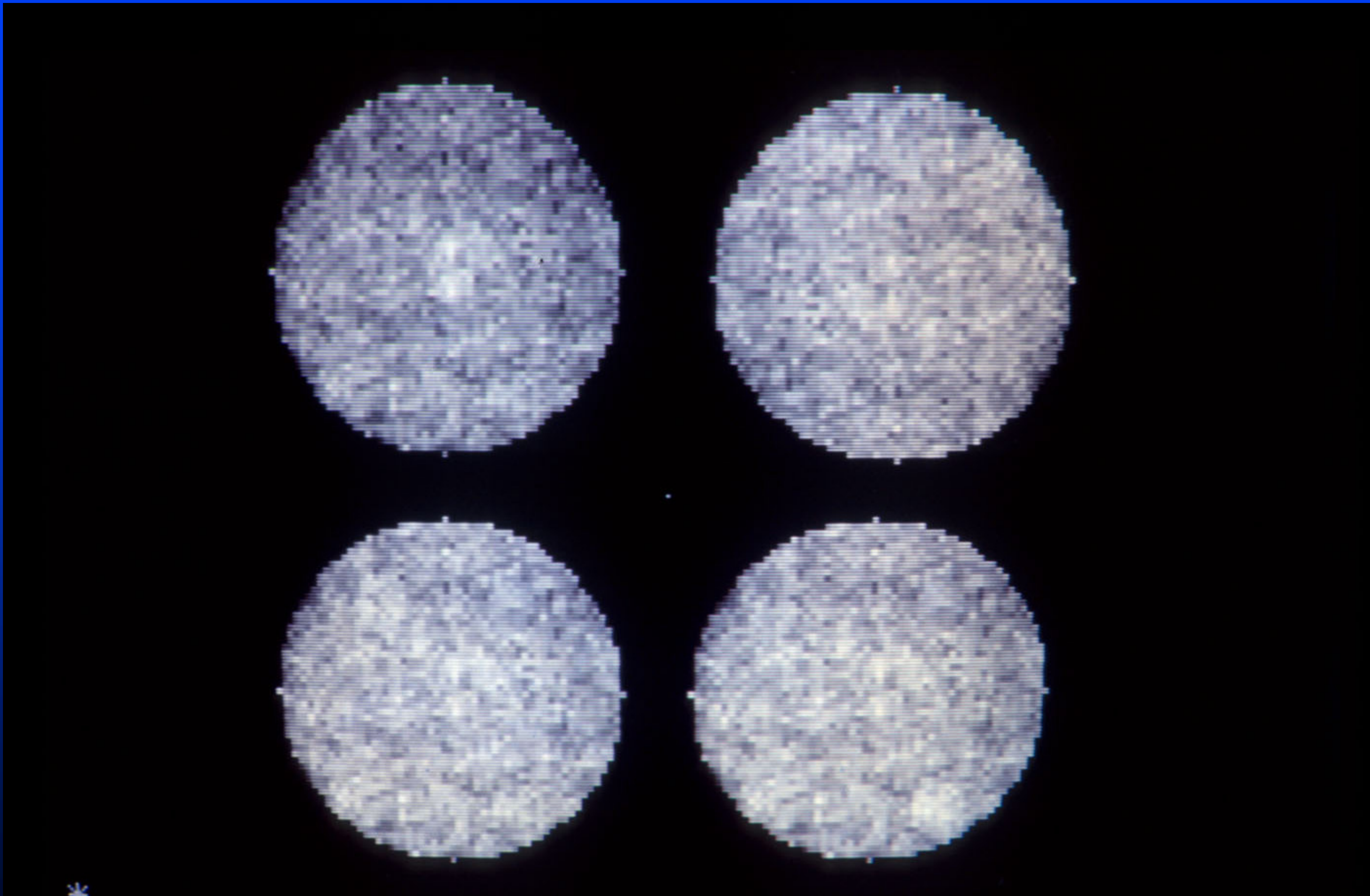
CLASSIFICATION :- assigning an image to one of a limited number of groups or classes

ESTIMATION :- measurement of a continuous parameter

CLASSIFICATION

↓

DETECTION :- assigning an image to one of TWO groups or classes



NEED TO SEE HOW IMAGE QUALITY FITS INTO THE WIDER CLINICAL PROBLEM

EFFICACY / EFFECTIVENSS

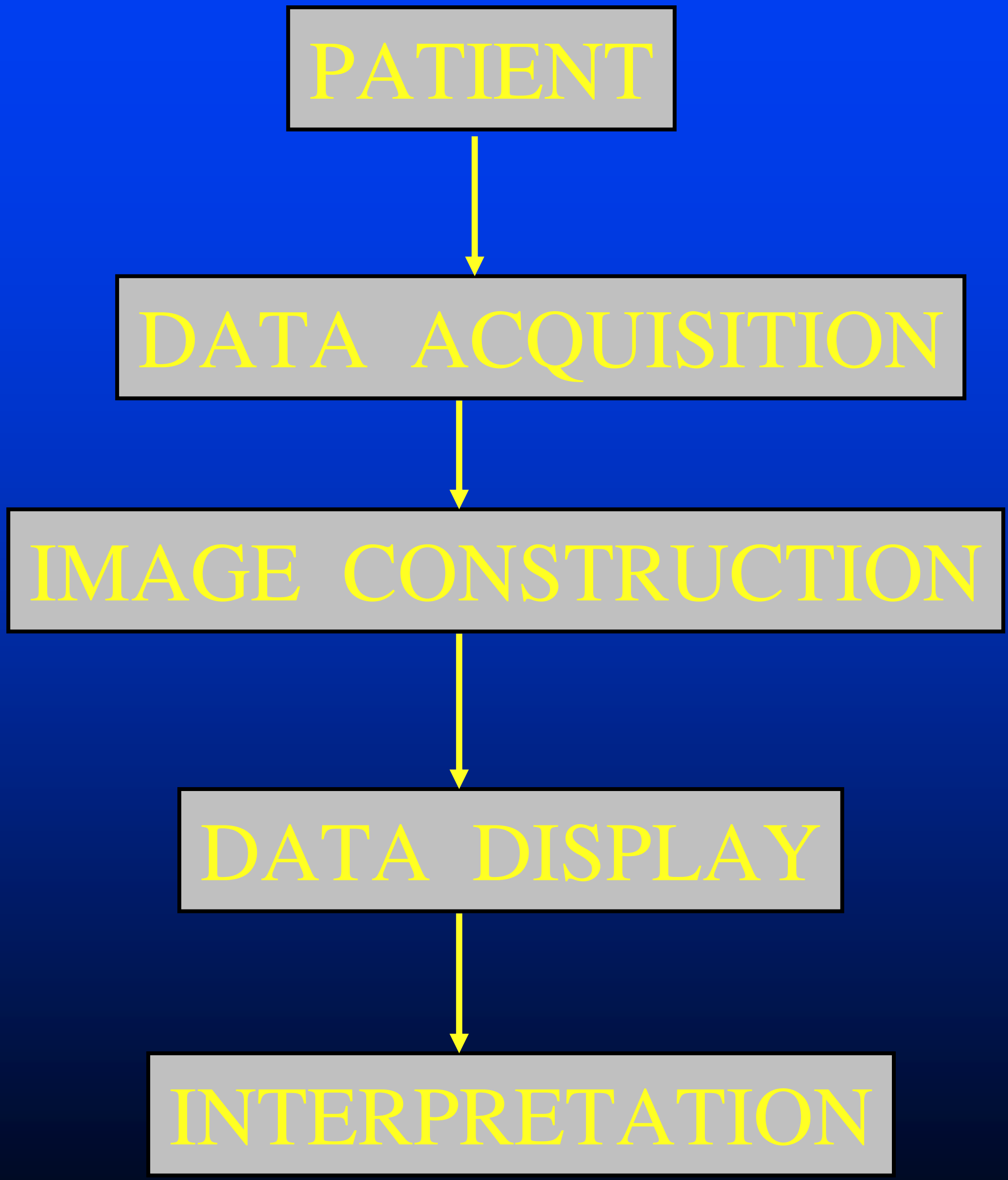
The probability of the medical technology benefiting people who have a specific medical problem.

EFFICACY

	LEVEL	OUTPUT MEASURE
1	TECHNICAL	MTF, NOISE
2	DIAGNOSTIC ACCURACY	SENSITIVITY, SPECIFICITY
3	DIAGNOSTIC THINKING	CHANGES IN CLINICIAN'S DIAGNOSTIC PROBABILITY

EFFICACY

QUALY IS **QU**ALITY OF **L**IFE **Y**EARS


PATIENT
DATA ACQUISITION
IMAGE CONSTRUCTION
DATA DISPLAY
INTERPRETATION

ACQUIRED DATA

↓

DISPLAYED DATA

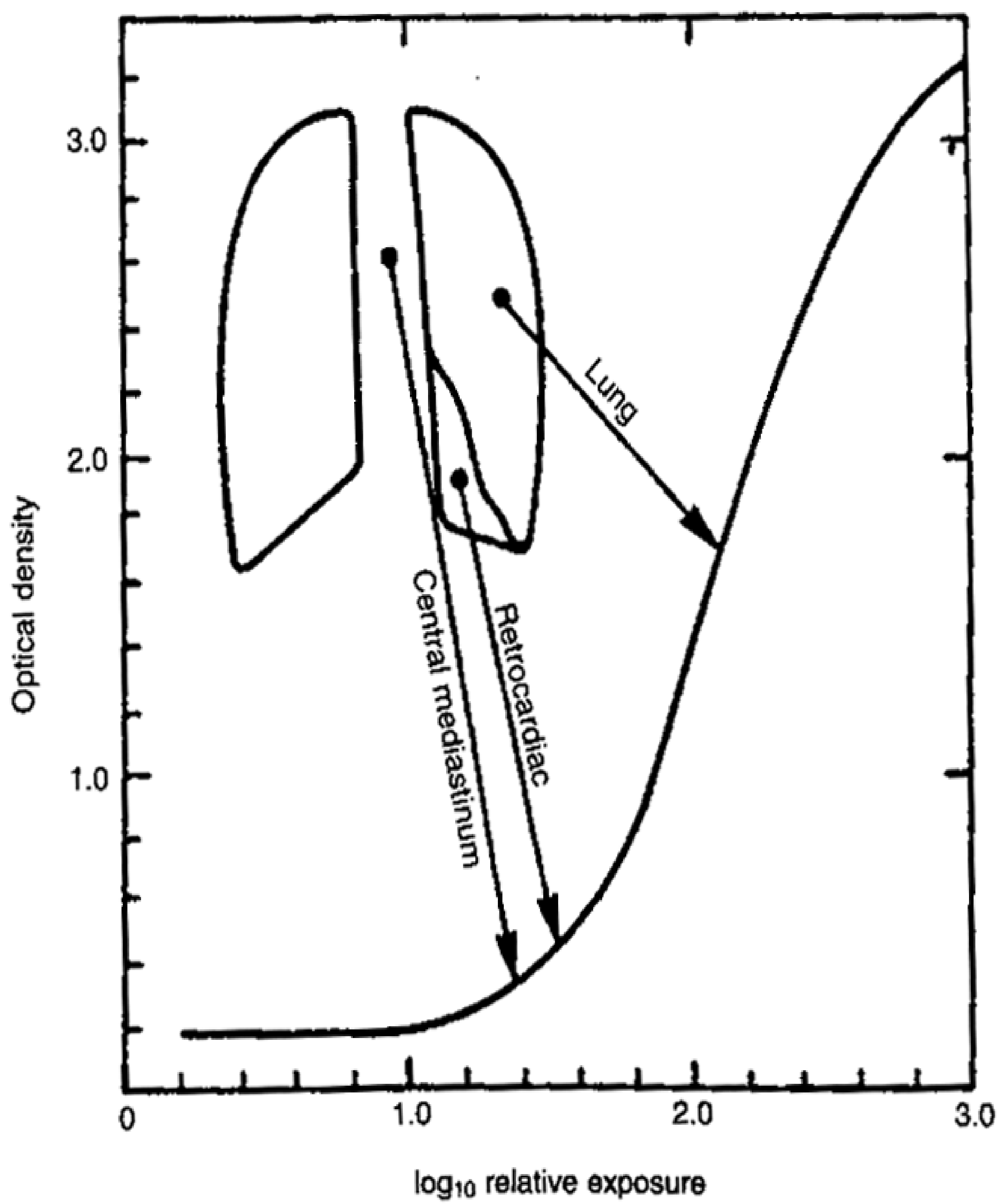
PHYSICAL FACTORS AFFECTING IMAGE QUALITY

1. LARGE AREA SYSTEM TRANSFER FACTOR
2. SPATIAL RESOLUTION
3. NOISE

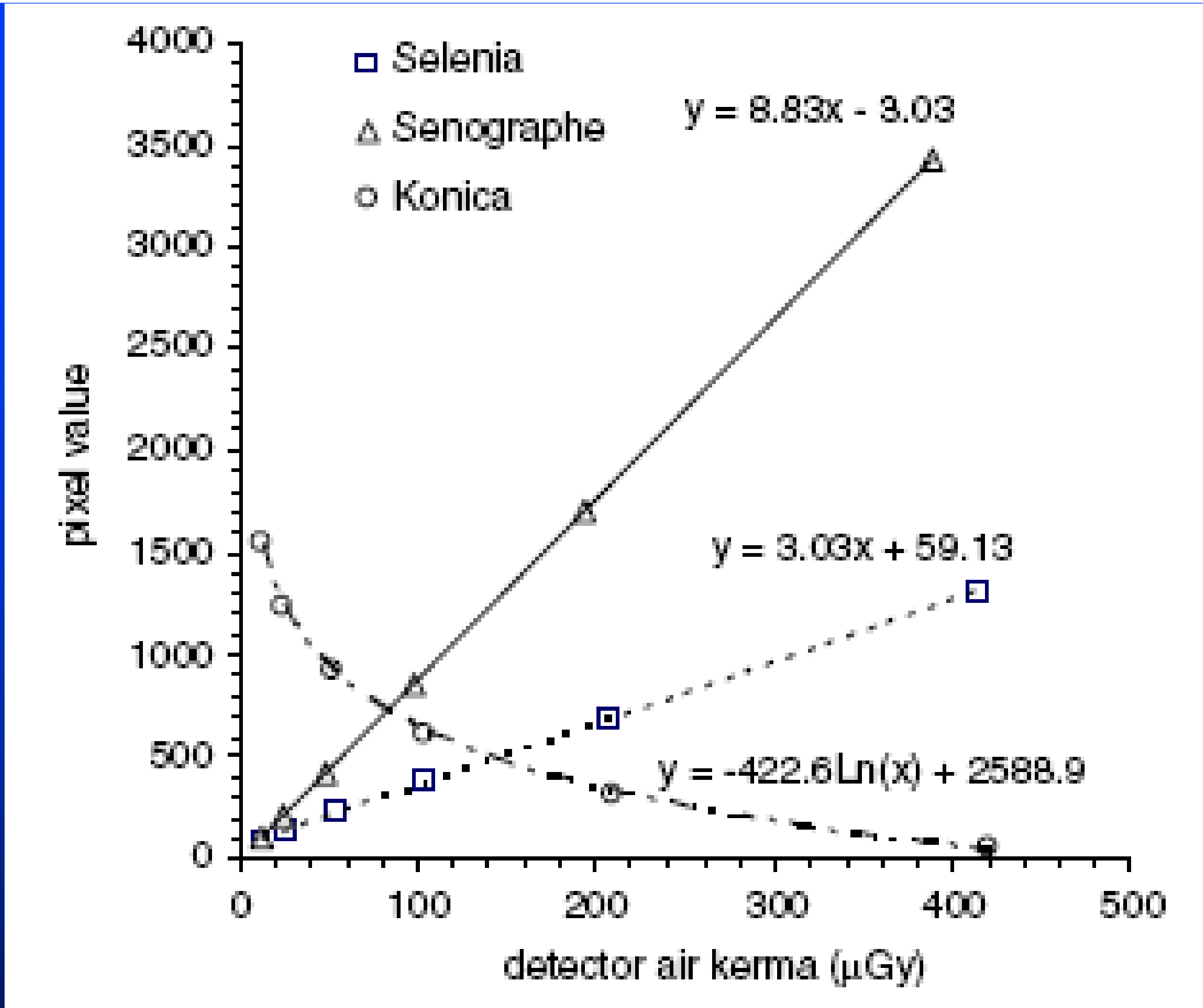
1. LARGE AREA TRANSFER FACTOR

The factor describing the scaling of information between the input and output of an imaging system.

Takes no account of spatial information.



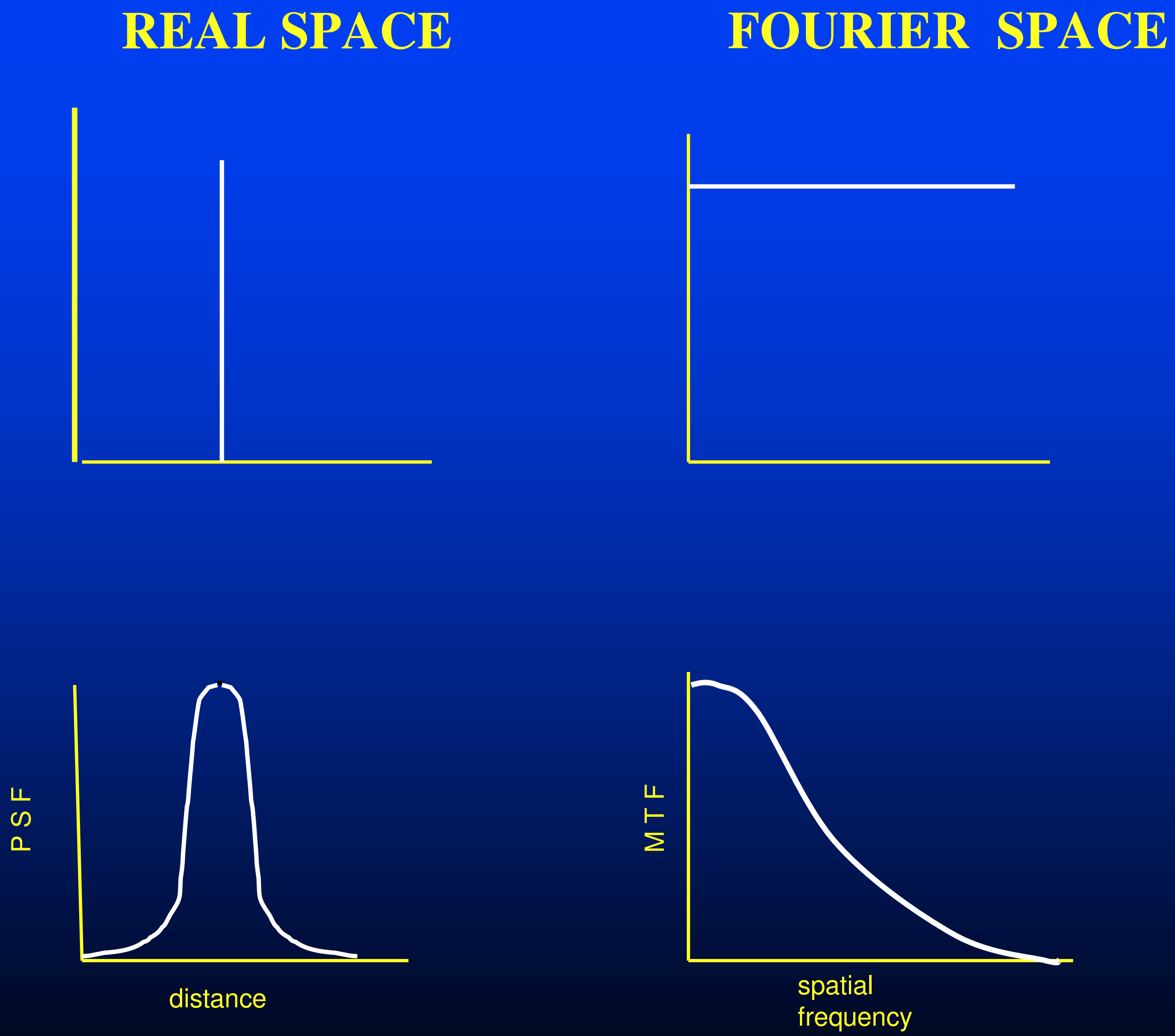
Optical density
3.0
2.0
1.0
0
1.0
2.0
3.0
log10 relative exposure
Lung
Central mediastinum
Retrocardiac

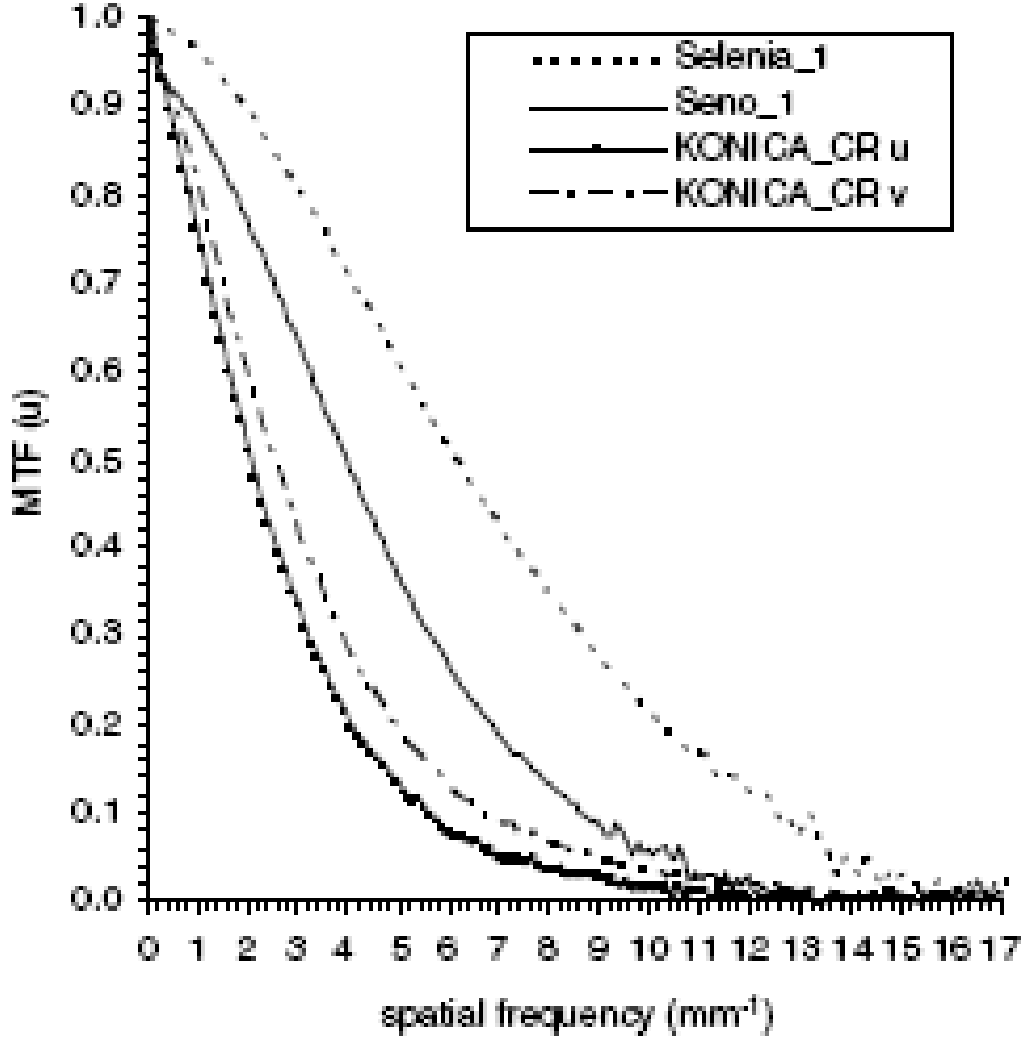


From Marshall NW Early experience in the use of quantitative image quality measurements for the quality assurance of full field digital mammography x-ray systems, Phys Med Biol, 2007;52:5545-5568

2. MODULATION TRANSFER FUNCTION

Relative amplitude of the output signal as a function of spatial frequency.


REAL SPACE
FOURIER SPACE
PSF
MTF
distance
spatial frequency



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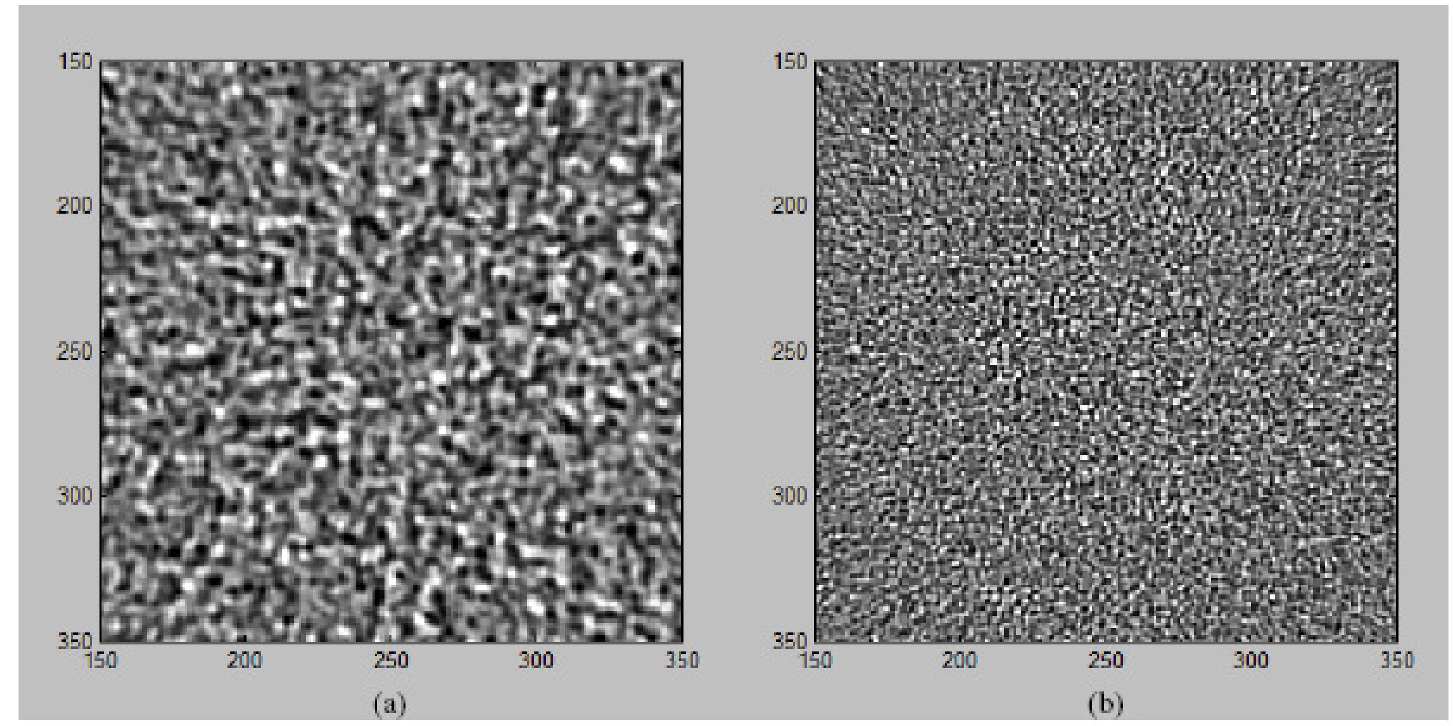
MEASUREMENT OF MTF

- Width of line or slit used must be small compared with the LSF.
- The length of the slit must be greater than 10 times the extent of the PSF.
- The sampling distance should be less than 12% of the FWHM of the LSF.
- The peak of the LSF should be at the centre of a pixel.

3. NOISE

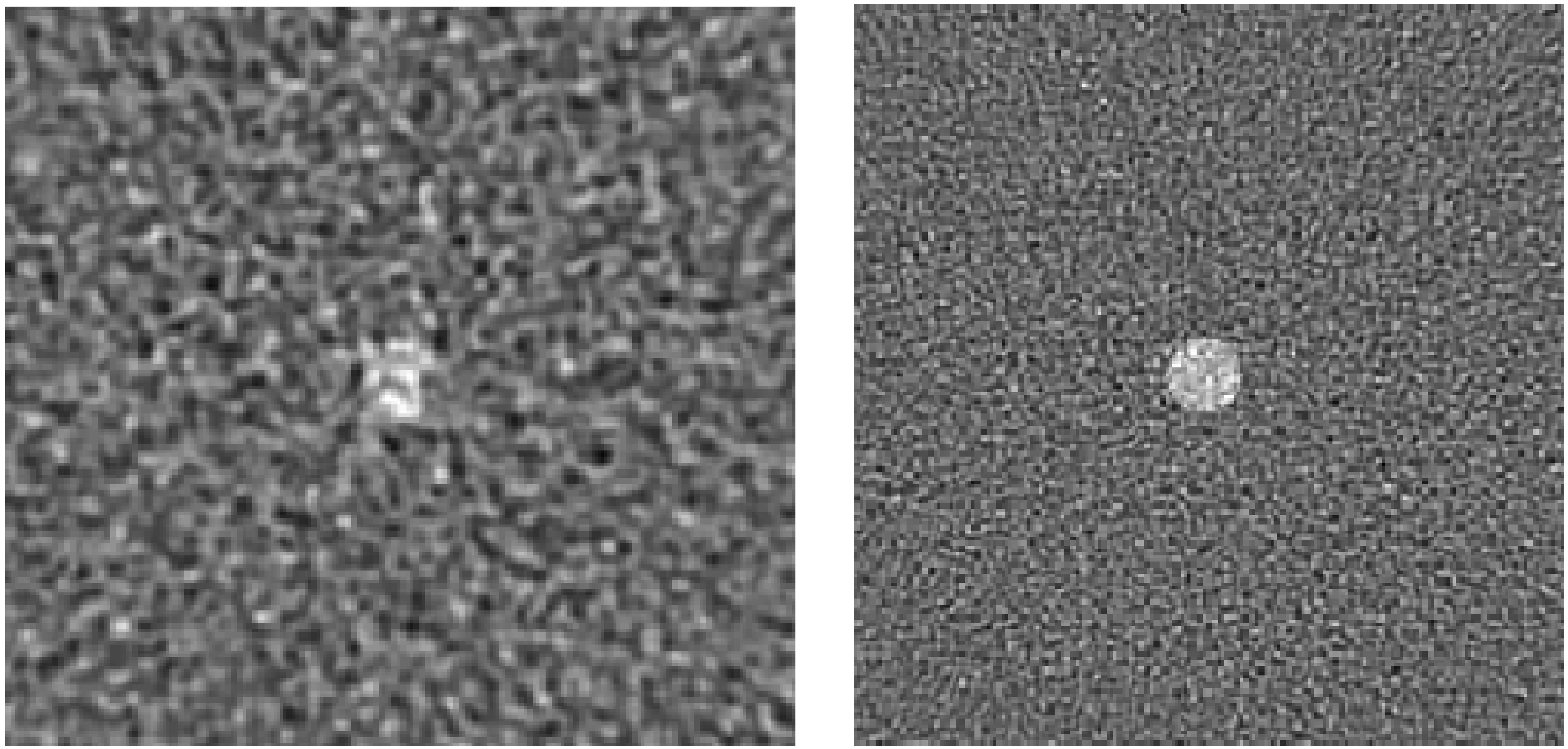
Standard deviation of the number of photons per image pixel.



Noise, as measured by standard deviation, is same in both images.

BUT,

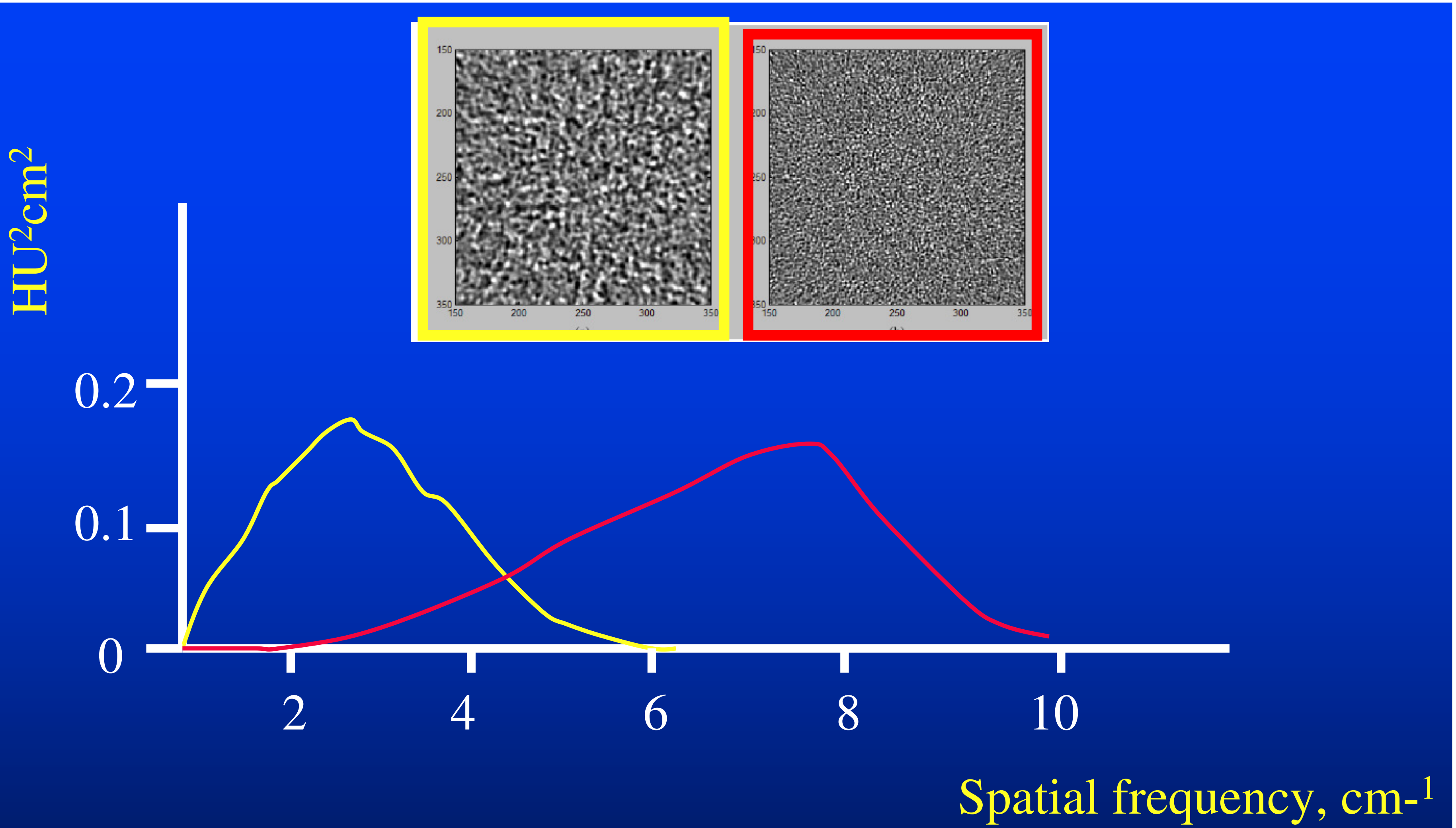
Takes no account of the spatial structure of the noise.



K L Boedeker and M F McNitt-Gray “Application of the noise power spectrum in modern diagnostic MDCT.” Phys Med Biol 52, (2007) 4047

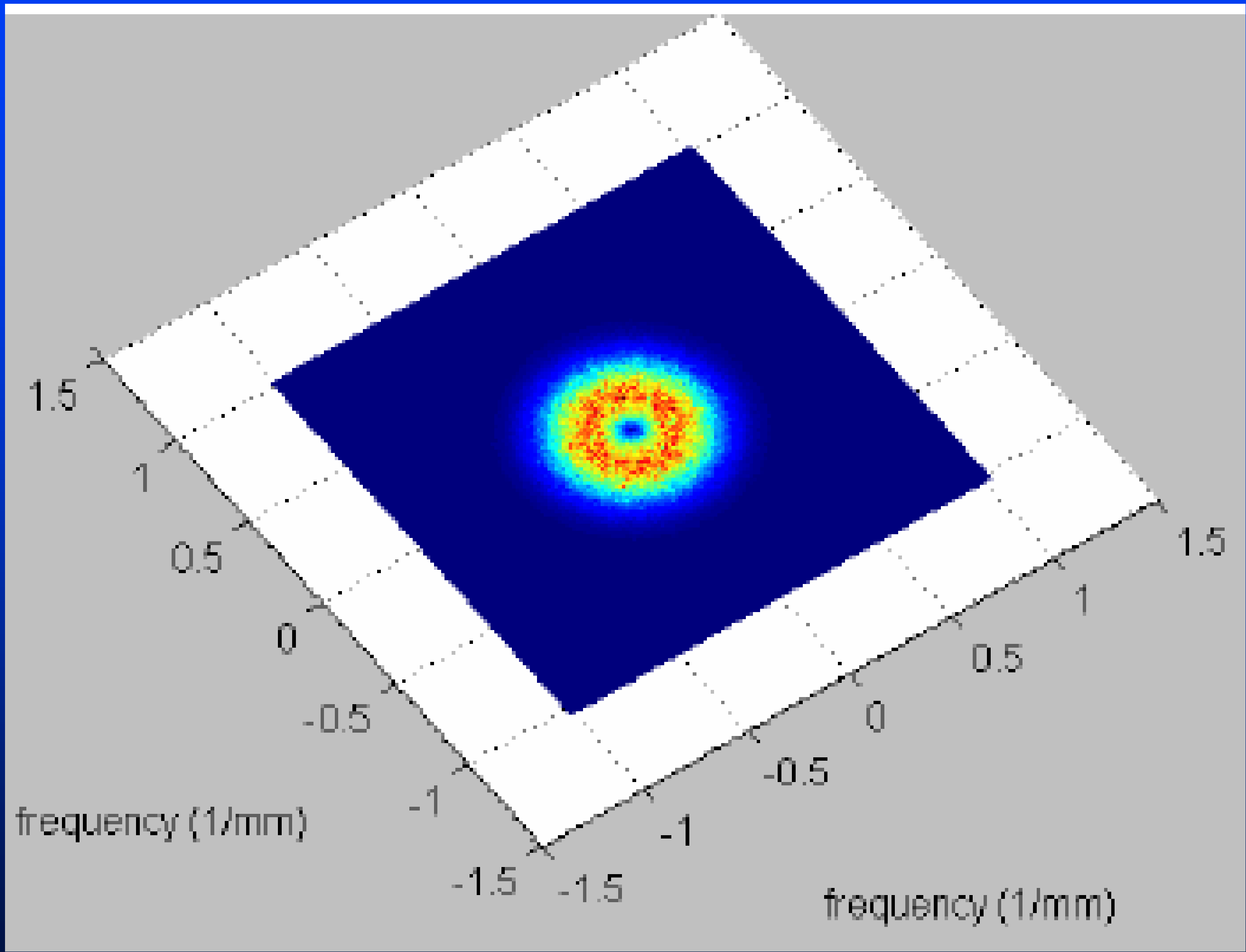
NOISE POWER OR WIENER SPECTRUM

The noise variance (i.e. standard deviation^2)
analysed in terms of
its spatial frequency content

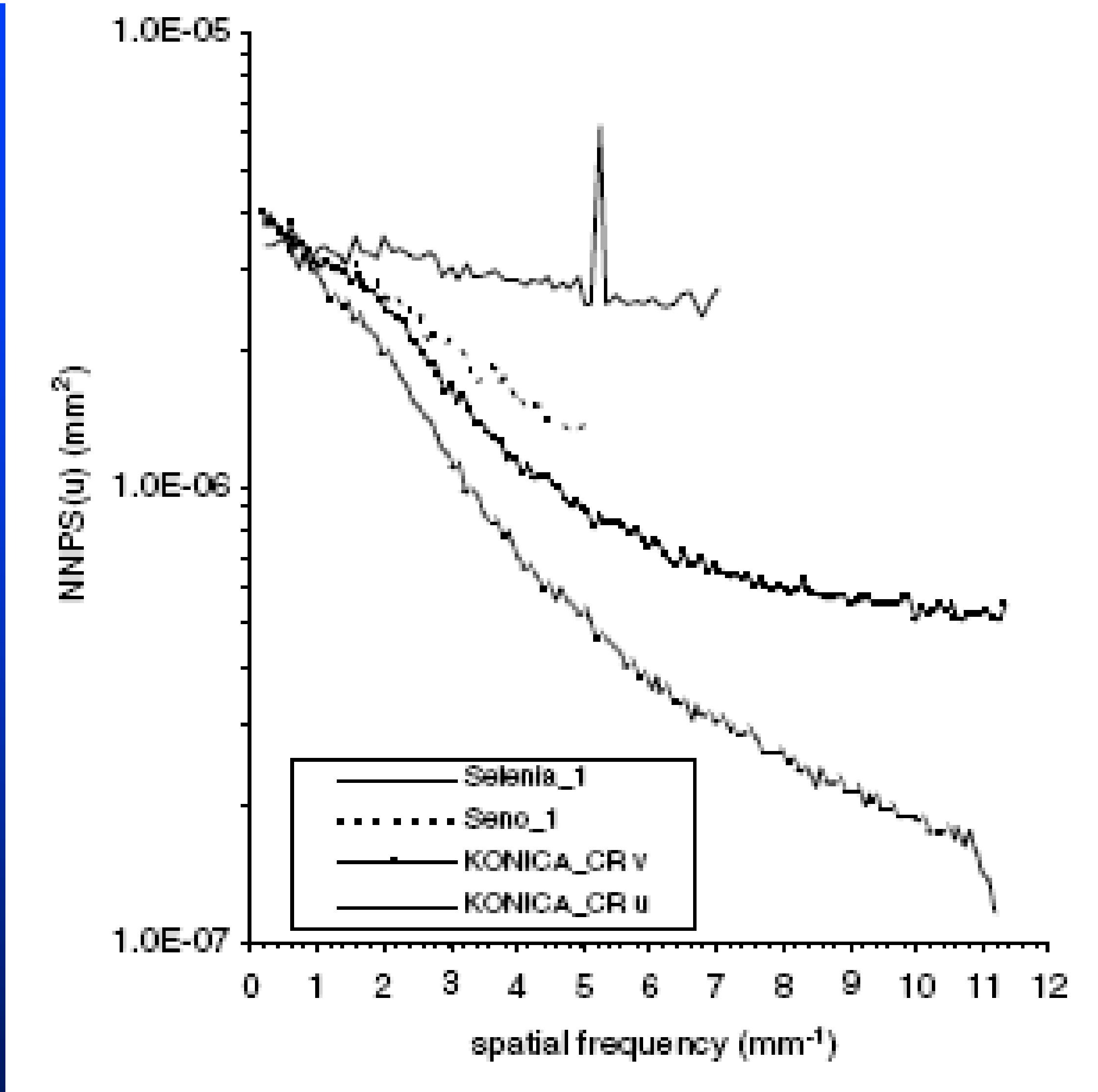


Adapted from Boedekker et al “Noise power spectra and noise equivalent quanta in modern diagnostic MDCT. Phys Med Biol 52, 4027-4046 (2007)

2D Noise Power Spectrum



From Boedekker et al "Noise power spectra and noise equivalent quanta in modern diagnostic MDCT. Phys Med Biol 52, 4027-4046 (2007)



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MEASURMENT OF NPS

1. Acquire a uniform image (i.e. noise only)
2. Select a ROI in which to measure the NPS
3. Subtract the mean from the data in the ROI
4. Fourier transform this data.
5. NPS (frequency)
   $= [(\text{Real part of FT})^2 + (\text{Imaginary part})^2] \div \text{Area of ROI}$

Area under the NPS = pixel variance

NOISE POWER SPECTRUM

(1D version of equation)

$$W_N(\upsilon) = \lim_{x\to\infty} \frac{1}{X} \left\langle \left| \int_{-X/2}^{X/2} dx\, e^{-2\pi i x}\, n(x) \right|^2 \right\rangle$$

Where n(x) is the noise at location x

and X the distance over which it is measured

HOW DO THEY INTERACT TO INFLUENCE THE DECISION MAKING PROCESS ?