DIGITAL RADIOGRAPHY DETECTORS QUALITY CONTROL

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Digital Radiography Detectors

Computed Radiography

- Radiography
- Mammography

Flat panel detector

- Radiography
- Mammography
- Angio/fluorography
- Cone Beam CT

Which tests?

Physical characterization of digital detector

System transfer proprieties (response curve)

DQE (MTF, NPS)

Quality checks

For CR

Dark noise, uniformity, image artefacts, erasure, cycle efficiency, Laser Beam Function…..

FOR DR

Dark noise, defective pixels/lines correction, Uniformity, Lag, Exposure Index at the detector, Image Quality measurements

Quality controls

Acceptance Test

Physical characterization of digital detectors

Quality check

Reference test

Constancy tests

Which tests?

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System transfer proprieties (response curve)

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Quality checks

For CR: dark noise, uniformity, image artefacts, erasure, cycle efficiency , Laser Beam Function…..

FOR DR: dark noise, defective pixels/lines correction, Uniformity, Lag

Exposure Index at the detector

Image Quality measurements

System transfer properties (Response curve)

It is necessary to establish the relationship between receptor dose and pixel value.

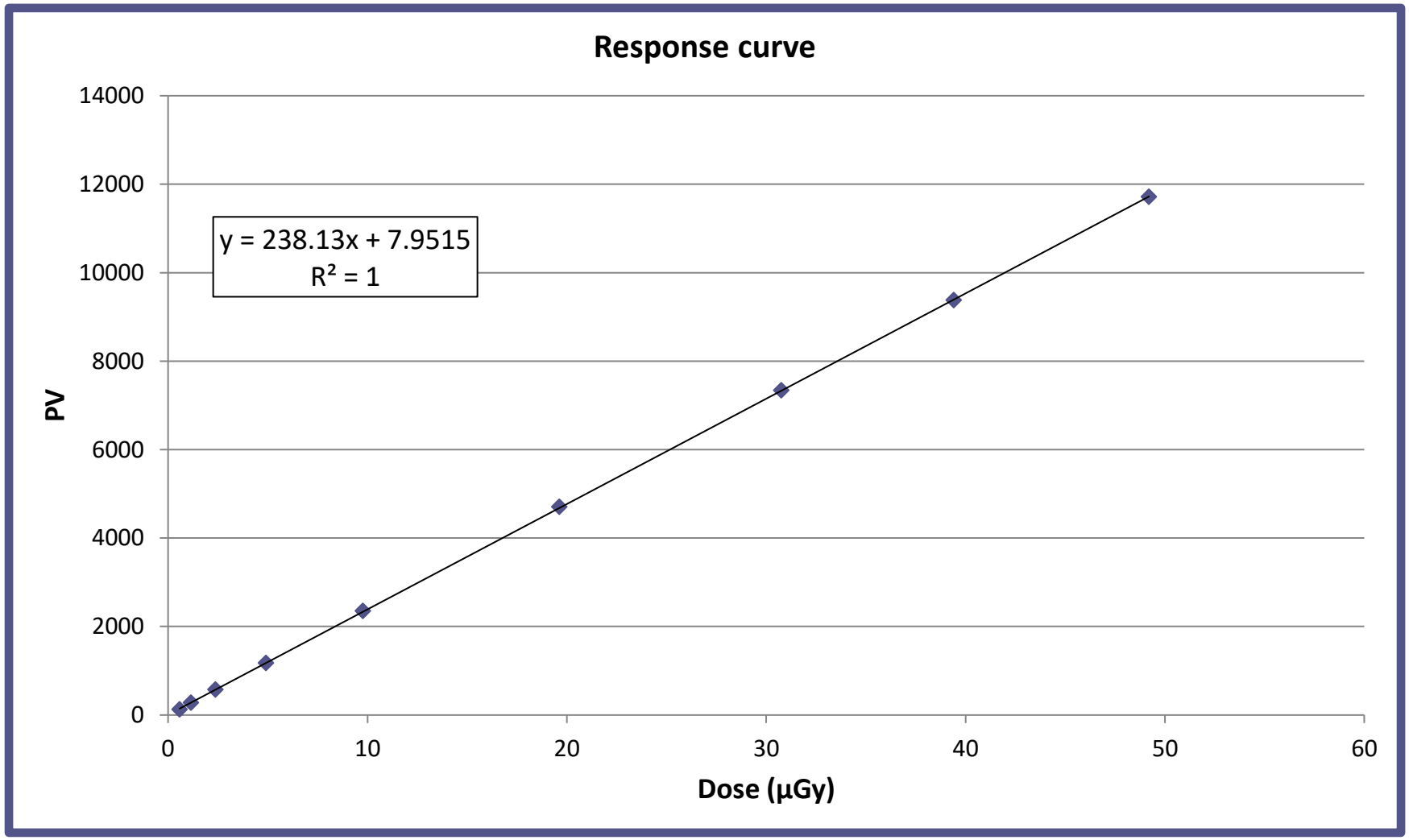
The response curve of all the systems is determined by exposing the detector to a wide range of uniform x-ray exposures. At each exposure, the average pixel values from a ROI located at the center of the detector is estimated

The pixel value to dose relationship is a simple relationship (e.g. **log**, **linear** or **square root**).

The trend-line should have a R^2 fit value > 0.95*

* *IPEM (other reference could be different)*

An example: DR system

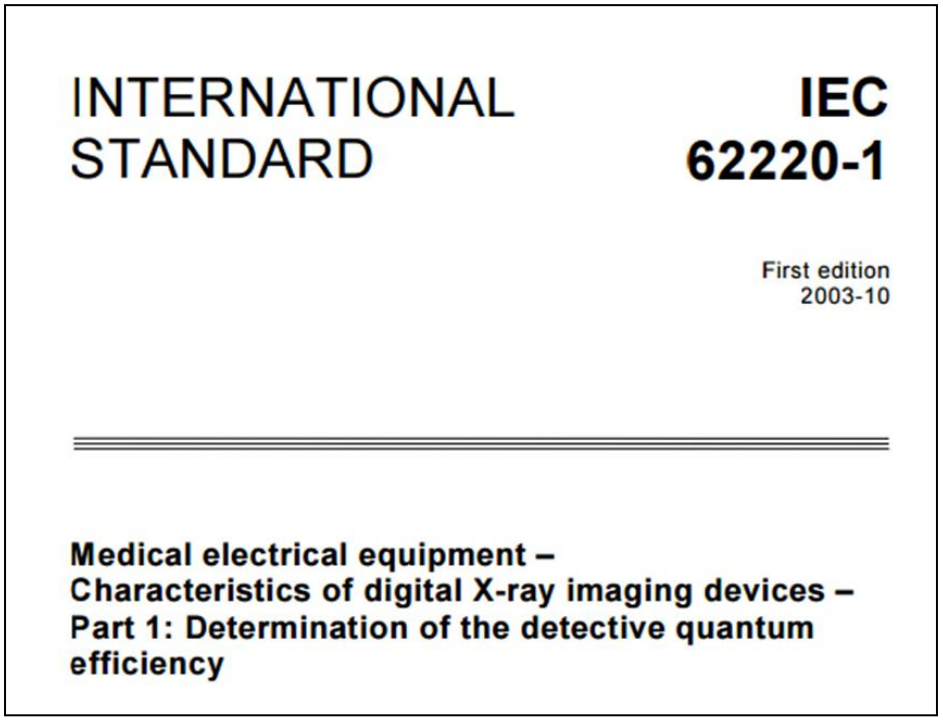


DQE (Detective Quantum Efficiency)

DQE describes how effectively an x-ray imaging system can produce an image with a high signal-to-noise ratio (SNR) relative to an ideal detector.
The DQE is the benchmark in the comparison of digital detectors.

Comparing different detectors, the system characterized by a higher DQE guarantees:

- An improvement of image quality at the same dose
- A decreasing of the dose at the same image quality


INTERNATIONAL STANDARD

IEC 62220-1

First edition
2003-10

Medical electrical equipment – Characteristics of digital X-ray imaging devices – Part 1: Determination of the detective quantum efficiency


IEC

IEC 62220-1-1

Edition 1.0 2015-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Medical electrical equipment – Characteristics of digital X-ray imaging devices – Part 1-1: Determination of the detective quantum efficiency – Detectors used in radiographic imaging

IEC 62220-1 (cancelled and replaced by IEC 62220-1-1) was developed in an effort to standardize methods and algorithms required to measure the DQE of digital x-ray imaging systems.

"….The intended users of this part of IEC 62220 are manufacturers and well equipped test laboratories"

Requirements

- Operating conditions
- X-ray equipment
- Radiation Quality
- Test device
- Geometry
- Irradiation conditions

Table 1 – RADIATION QUALITY (IEC 61267:1994) for the determination of DETECTIVE QUANTUM EFFICIENCY and corresponding parameters

RADIATION QUALITY No.	Approximate X-RAY TUBE VOLTAGE kV	HALF-VALUE LAYER (HVL) mm Al	ADDITIONAL FILTRATION mm Al
RQA 3	50	4,0	10,0
RQA 5	70	7,1	21,0
RQA 7	90	9,1	30,0
RQA 9	120	11,5	40,0

DQE: definition and formula

$$DQE(u,v) = MTF^2(u,v)\frac{W_{in}(u,v)}{W_{out}(u,v)}$$

where

MTF(u,v)	is the sampling MODULATION TRANSFER FUNCTION of the DIGITAL X-RAY IMAGING DEVICE
$W_{in}(u,v)$	is the NOISE POWER SPECTRUM of the radiation field at the DETECTOR SURFACE
$W_{out}(u,v)$	is the NOISE POWER SPECTRUM at the output of DIGITAL X-RAY IMAGING DEVICE

From IEC 62220-1

DQE: definition and formula

For the determination of the DETECTIVE QUANTUM EFFICIENCY, the value of the input NOISE POWER SPECTRUM $W_{in}(u,v)$ shall be calculated as:

$$W_{in}(u,v) = K_a SNR_{in}{}^2$$

where

K_a is the measured AIR KERMA (unit: µGy)

$SNR_{in}{}^2$ is the squared signal-to-NOISE ratio per AIR KERMA (unit: $1/(mm^2 \cdot \mu Gy)$), as reported in the Table

Parameters mandatory for the application of this standard	
Radiation Quality	**$SNR_{in}{}^2$ [$1/(mm^2 \cdot \mu Gy)$]**
RQA3	21759
RQA5	30174
RQA7	32362
RQA9	31077

From IEC 62220-1

MTF evaluation

- The image of a tungsten edge test device is acquired
- An oversampled line spread function is derived by slightly rotating about 2°–4° the test device
- Discrete Fourier transform is applied to line spread function to obtain MTF

The MTFs is measured in both the horizontal and vertical directions. For DQE calculation, the average of the MTF along the two directions is considered

E. Samei, M. J. Flynn, and D. A. Reimann, "A method for measuring the presampled MTF of digital radiographic systems using an edge test device," Med. Phys. 25, 102–113 1998

NPS (Noise Power Spectrum)

- NPS is computed by using flat field images at three different exposure levels around 2.5, 5, and 10 µGy.
- For each exposure level, four images is acquired. A fixed ROI was extracted from each image and subdivided into 256x256 regions.
- The 2D normalized noise power spectrum NNPS is then derived by averaging square modulus of the Fourier transform of each sub-ROI.
- The result is normalized for the square mean signal value of the ROI.
- The 1D NNPS was then extracted from the 2D NNPS on a radial direction at 45°, excluding the values along the axes.

KEY POINTS TO REMEMBER

Linearization of data is required

The linearized data are calculated by applying the inverse response function to the original data on an individual pixel basis.

Analysis are performed on **RAW DATA**!!!

Computed Radiography

Image plate Reader (example: KODAK)

The appearance of the displayed image is tailored through a variety of image processing techniques .

For each anatomical district a prefixed processing technique is available . It shall be selected when the cassette is put in the reader

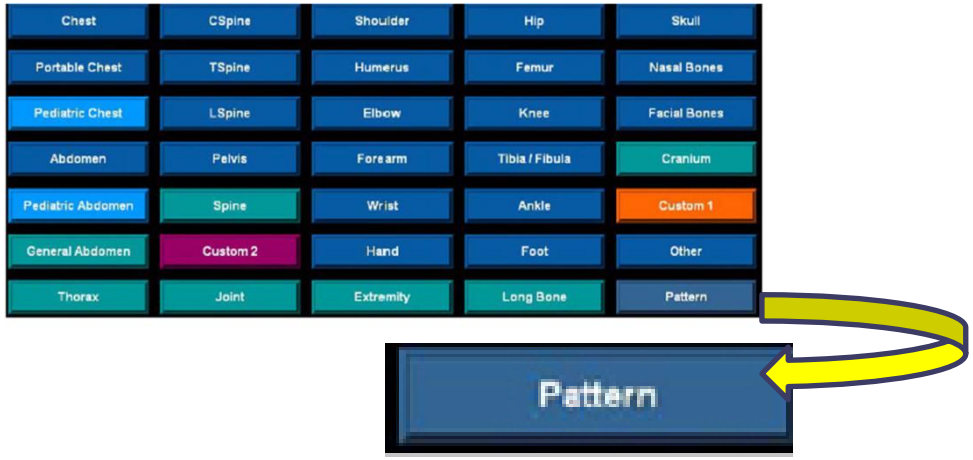
Computed Radiography

Image plate Reading Parameter shall be properly selected, in order to **disable post-processing**

How?

The answer is depending on the manufacturer

Some Examples



- **Kodak**

  MODE: Pattern

- **Agfa**

  S (exposure class): 200

  MENU: System Diagnosis/Flat Field

  SENSITOMETRY: linear

- **Fuji**

  MODE : Semi-Auto (L=2) o FIX

- **Konica**

  MODE : FIX

DR – DICOM FOR PROCESSING

DR systems can export two digital images

DICOM for processing

DICOM for presentation (for clinical use)

DICOM for processing are not really RAW DATA: detector corrections are applied and cannot be de-selected:

- The RAW DATA of bad or defective pixels may be replaced by appropriate data as in normal clinical use.
- A flat-field correction comprising correction of the non-uniformity of the radiation field, correction for the offset of the individual pixels and gain correction for the individual pixels may be applied as in normal clinical use.
- A correction for geometrical distortion may be made as in normal clinical use

Exporting DICOM FOR PROCESSING

Non always available as a default

(DICOM FOR PROCESSIG images have not a clinical use)

Not always avalible at all!!

(equipment for vascular and interventional radiology, neuroradiology and cardiology)

Futhermore, export to ….???

PACS (compressed images..)

USB (from the modality)

DVD (from the modality)

DEPARTMENT OF PHYSICS
MEDICAL IMAGING

Department of Physics | Contact us

ImageJ plugin for performing physical characterization and quality checks

The download of the ImageJ plugin (.jar) can be done here.

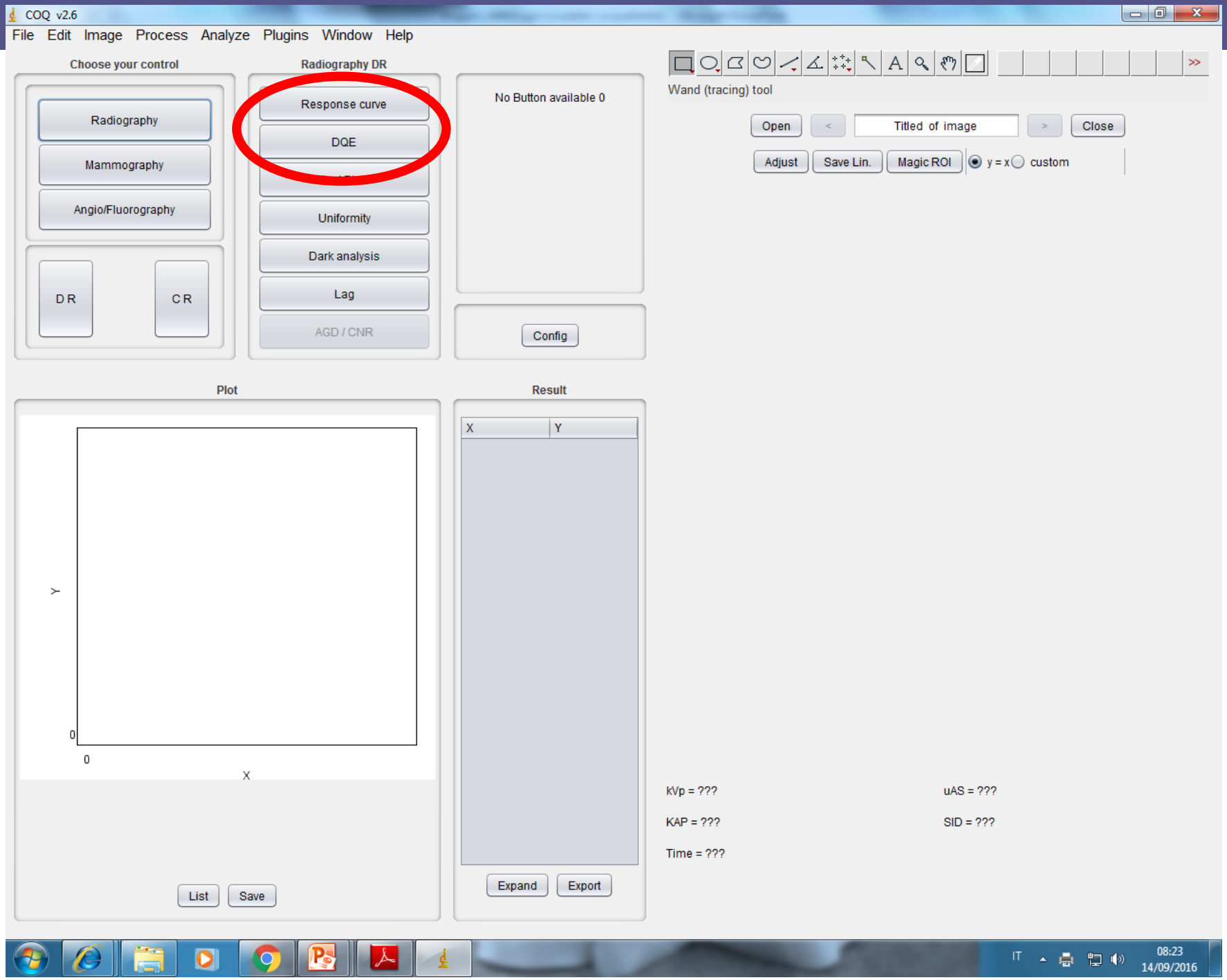
To install this plugin, unzip the archive, copy the file COQ_.jar to the ImageJ plugins folder, and restart ImageJ.

This software was developed for assisting users in achieving the physical characterization of X-ray digital systems and some image quality checks. It can be used for calculating various physical parameters such as the response curve, Modulation Transfer Function (MTF), Noise Power Spectra (NPS), Detective Quantum Efficiency (DQE). It also includes the computation of some image quality checks: defective pixel analysis, uniformity, dark analysis, and lag.

If you use this software, please credit this website and reference the following paper:

"Free software for performing physical analysis of systems for digital radiography and mammography", Bruno Donini, Stefano Rivetti, Nico Lanconelli and Marco Bertolini , *Med. Phys.*, Vol. 41(5), 051903 (2014).

http://www.medphys.it/down_dqe.htm


COQ v2.6
File Edit Image Process Analyze Plugins Window Help
Choose your control
Radiography
Mammography
Angio/Fluorography
D R
C R
Radiography DR
Response curve
DQE
Uniformity
Dark analysis
Lag
AGD / CNR
No Button available 0
Config
Wand (tracing) tool
Open
Titled of image
Close
Adjust
Save Lin.
Magic ROI
y = x
custom
Plot
Y
0
0
X
List
Save
Result
X
Y
Expand
Export
kVp = ???
uAS = ???
KAP = ???
SID = ???
Time = ???
IT
08:23
14/09/2016

Which tests?

Physical characterization of digital detector

System transfer proprieties (response curve)

DQE (MTF, NPS)

Quality checks

For CR: dark noise, uniformity, image artefacts, erasure, cycle efficiency , Laser Beam Function…..

FOR DR: dark noise, defective pixels/lines correction, Uniformity, Lag, Exposure Index at the detector, Image Quality measurements

CR: References

Report 90 of Task Group # 10 - AAPM

Acceptance Testing and Quality Control of Photostimulable Storage Imaging Systems [2006]

Technical and Scientific Bulletin - Eastman Kodak Company

Guidelines for Acceptance testing and Quality Control: Kodak DirectView CR 900/950 System

IPEM 91

Reccomanded Standards for the routine preformance testing od diagnostic X-Ray Imaging Systems [2005]

CR: References

KCARE

Protocols for QA of CR Systems (last Release: 2005)

- Commissionig and Annual QA tests
- Routine QA tests

Manufacturers:Agfa; Fuji; Kodak (Carestream); Konica

Radiation Protection 162

Criteria for acceptability of Medical Radiological Equipemt used in diagnostic radiology, Nuclear Medicine and Radiotherapy [2012]

CR: CQ Tools for “Physicist”

Equipment:

- Copper and Alluminium filter
- Detector (ionisation chamber or solid state detector)
- Lead Block (5 x 5 cm)
- Steel ruler
- Image Quality Phantom

The tests should be performed using an x-ray unit that has recently passed QC tests.

In particular, the accuracy of the kVp selected for detector dose indicator consistency and calibration should be tested.

CR: Vendor CQ Tools

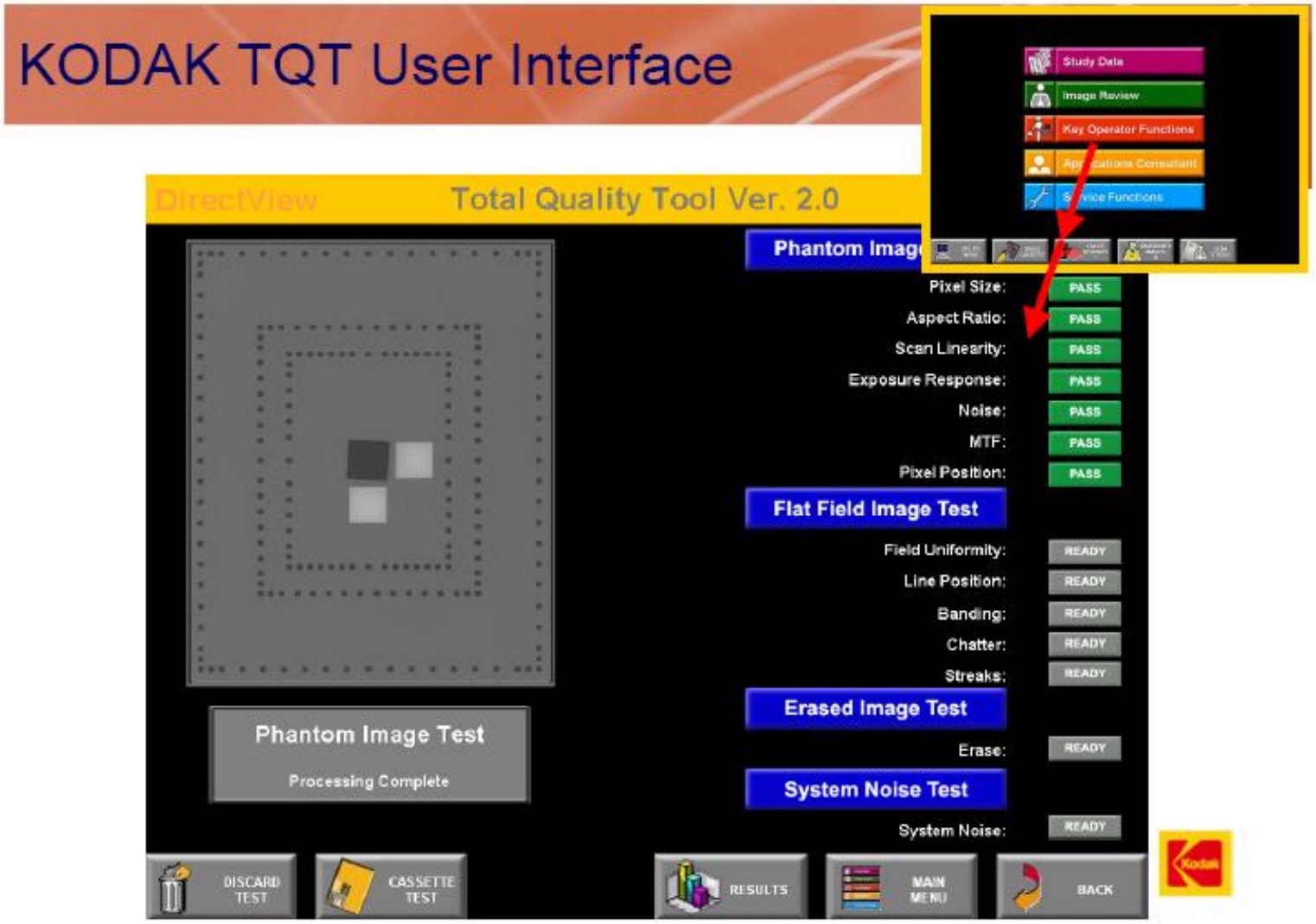
AGFA: AUTO QC²

- Agfa unique CR test phantom
- AUTO QC2 software

Fuji

FCR One Shot Phantom Plus

CR: Vendor CQ Tools



CR: Vendor CQ Tools

Phantom Image Test Results

Pixel Size 2.0% max:	1.4%
Aspect Ration 3.0% max:	2.7%
Scan Non-Linearity 2.0% max:	0.95%
Exposure Latitude 100.0 max:	76.4
Noise Level (@0.19mR) 13.3 max:	11.9
Noise Level (@2.11mR) 11.3 max:	10.7
Noise Level (@10.0mR) 10.3 max:	9.12
Pixel Placement Error 0.25 max:	0.114
MTF (short direction @ 50% Nyquist) 34.5% min:	59.5%
MTF (short direction @ 95% Nyquist) 10.3% min:	21.7%
MTF (long direction @ 50% Nyquist) 34.5% min:	29.5%
MTF (long direction @ 50% Nyquist) 10.3% min:	10.9%

Flat Field Image Test Results

Field Non-Uniformity 100max:	74.9
Galvo Function 5.0E+06 max:	3.7E+06
Transport Banding 810.0 max:	715.7
Random Streak 5 max:	2

Erased Image Test Results

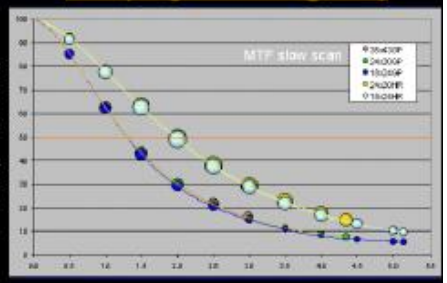
Residual Signal 100.0 max:	Not Available

System Noise Test Results

BaseLine System Noise 6.0E-06 max:	Not Available

Select test result to display graph

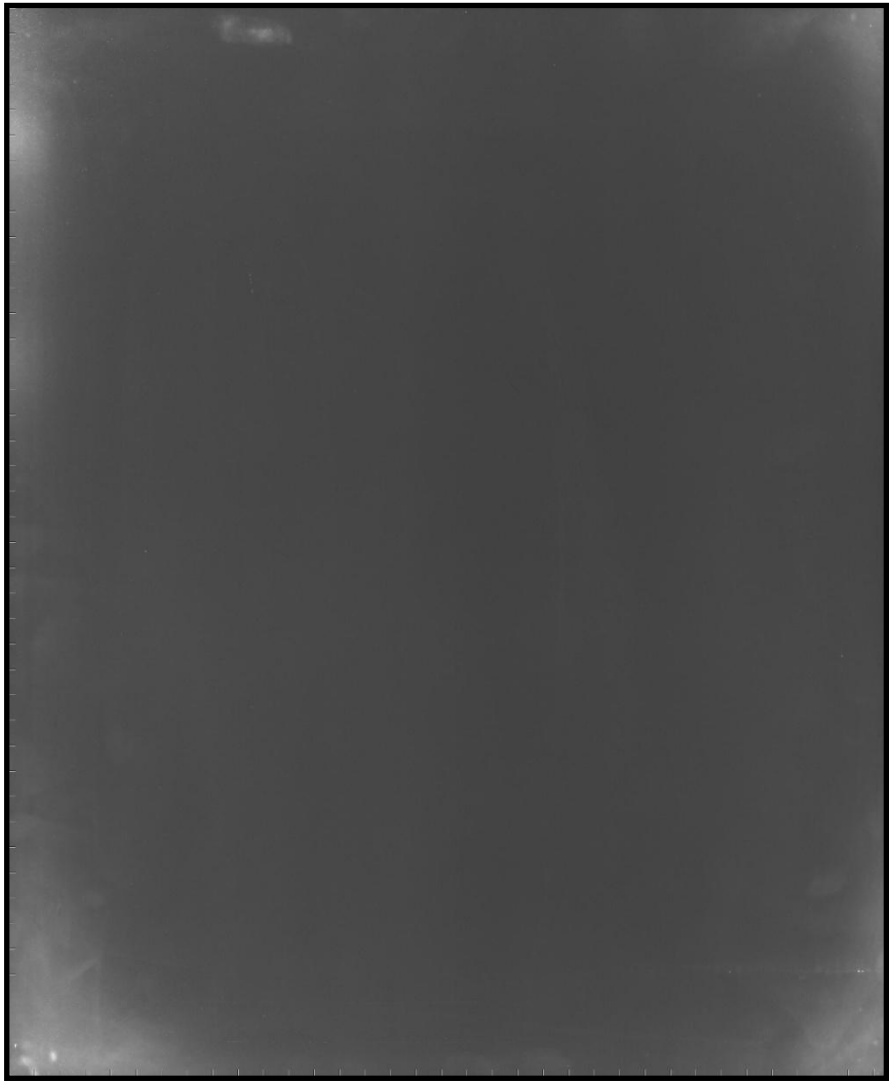
MTF (long direction @ 50%)



Previous 8 results of MTF

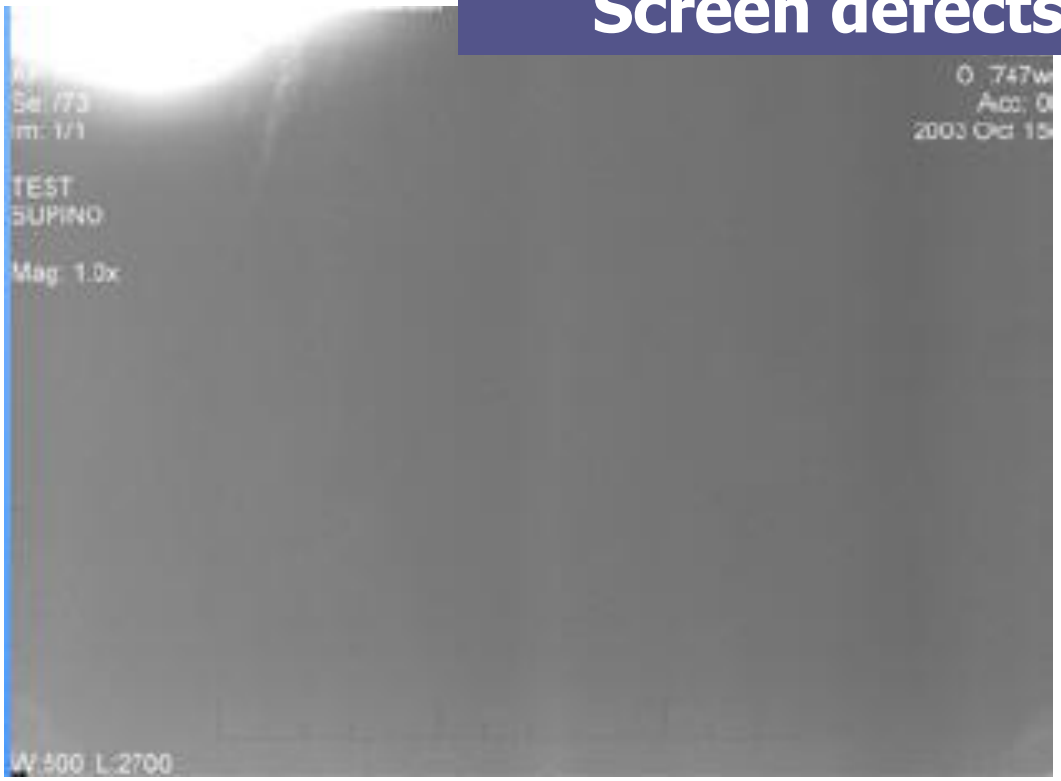
Phantom Test	Flat Field Test		Erased Test		System Noise Test			
Date	2000/07/17	2000/07/17	2001/01/05	2001/01/05	2000/07/17	2000/07/17	2000/07/17	2000/07/17	2000/07/17
Cassette ID	9104000004	9104000004	9104037750	9104037750	9104000004	9104000004	9104000004	9104000004	9104000004
Pass/Fail	FAIL	FAIL	PASS	PASS	FAIL	FAIL	FAIL	FAIL	FAIL
Pixel Size Error Fast(%)	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
Pixel Size Error Slow(%)	0	0	0	0	0	0	0	0	0
Aspect Ratio Error Left(%)	1.2	1.2	1.8	1.8	1.2	1.2	1.2	1.2	1.2
Aspect Ratio Error Middle(%)	0.7	0.7	0.9	0.9	0.7	0.7	0.7	0.7	0.7
Aspect Ratio Error Right(%)	0.4	0.4	0.1	0.1	0.4	0.4	0.4	0.4	0.4
Aspect Ratio Error Average(%)	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5
Fast-Scan Speed Error(%)	0.12	0.12	0.33	0.33	0.12	0.12	0.12	0.12	0.12
Slow-Scan Speed Error(%)	0.05	0.05	0.02	0.02	0.05	0.05	0.05	0.05	0.05
Low-Exposure Response Error(CV)	33.6	33.6	20.7	20.7	33.6	33.6	33.6	33.6	33.6
Mid-Exposure Response Error(CV)	4.1	4.1	5.2	5.2	4.1	4.1	4.1	4.1	4.1
High-Exposure Response Error(CV)	109	109	46.9	46.9	109	109	109	109	109
Low-Exposure Noise(CV)	12	12	13.4	13.4	12	12	12	12	12
Mid-Exposure Noise(CV)	4.3	4.3	4.8	4.8	4.3	4.3	4.3	4.3	4.3
High-Exposure Noise(CV)	3.2	3.2	3.6	3.6	3.2	3.2	3.2	3.2	3.2
Fast-Scan MTF @50% Nyquist(%)	41.4	41.4	43.6	43.6	41.4	41.4	41.4	41.4	41.4
Fast-Scan MTF @95% Nyquist(%)	12.4	12.4	13.1	13.1	12.4	12.4	12.4	12.4	12.4
Slow-Scan MTF @50% Nyquist(%)	43.2	43.2	45.8	45.8	43.2	43.2	43.2	43.2	43.2
Slow-Scan MTF @95% Nyquist(%)	16.6	16.6	19.7	19.7	16.6	16.6	16.6	16.6	16.6
Pixel Position RMS(pixels)	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.03

CR: Uniformity and artifact



CRITICAL TEST

CR: Uniformity and artifact



Origin of the problem

- Screening cleaning procedures not correctly applied
- Screen defects

FLAT PANEL

Radiography
Fluoroscopy
Mobile
Wireless

DR: References (radiography)

KCARE

Protocols for QA of Direct digital Systems

- Commissioning and Annual QA Test [2005]

IPEM 91

Recomanded Standards for the routine preformance testing od diagnostic X-Ray Imaging Systems [2005]

Radiation Protection 162

Criteria for acceptability of Medical Radiological Equipemt used in diagnostic radiology, Nuclear Medicine and Radiotherapy [2012]

AAPM Task group 150

AAPM COMMITTEE TREE

Task Group No. 150 - Acceptance Testing and Quality Control of Digital Radiographic Imaging Systems (TG150)

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Committee Website | **Directory:** Committee | Membership

Email	You may send email to this group now using gmail or outlook. - or - You may save the address *2018.TG150@aapm.org* to your local address book. This alias updates hourly from the AAPM Directory.
Charge	This group will outline a set of tests to be used in the Acceptance Testing and Quality Control of Digital Radiographic Imaging Systems.
Bylaws:	Not Referenced. **Rules:** Not Referenced.
Approved Date(s)	12/31/2018
Committee Keywords:	TG150
Most recent status update:	7/27/2018 3:35:19 PM - The report is almost complete. The task group is is beginning a detailed review of the report during monthly teleconferences, and plans to have a final version ready to advance to the R&F Subcommittee by RSNA. Click to update.

DR: dark noise

Purpose: To assess the level of noise inherent in the system

If possible, remove the grid from the system

Close the collimators and cover the detector with a lead apron. Set a low exposure e.g. 50kVp and 0.5mAs. This will give an effectively zero dose, or 'dark noise' image

Record the detector dose indicator value, and pixel value.

<u>Tolerance</u>

Acceptance test is used to set a baseline for future QA tests

In constancy test, the difference between pixel values and standard deviation with reference values should be < 10%

DR: Defective pixels/lines

Purpose: To determine the accuracy of the defective pixels/lines correction in the preprocessing stage.

A defective pixel is defined as an element within a 1 x 1 cm ROI where its absolute value deviates more than 20% from the mean pixel value of the ROI elements.

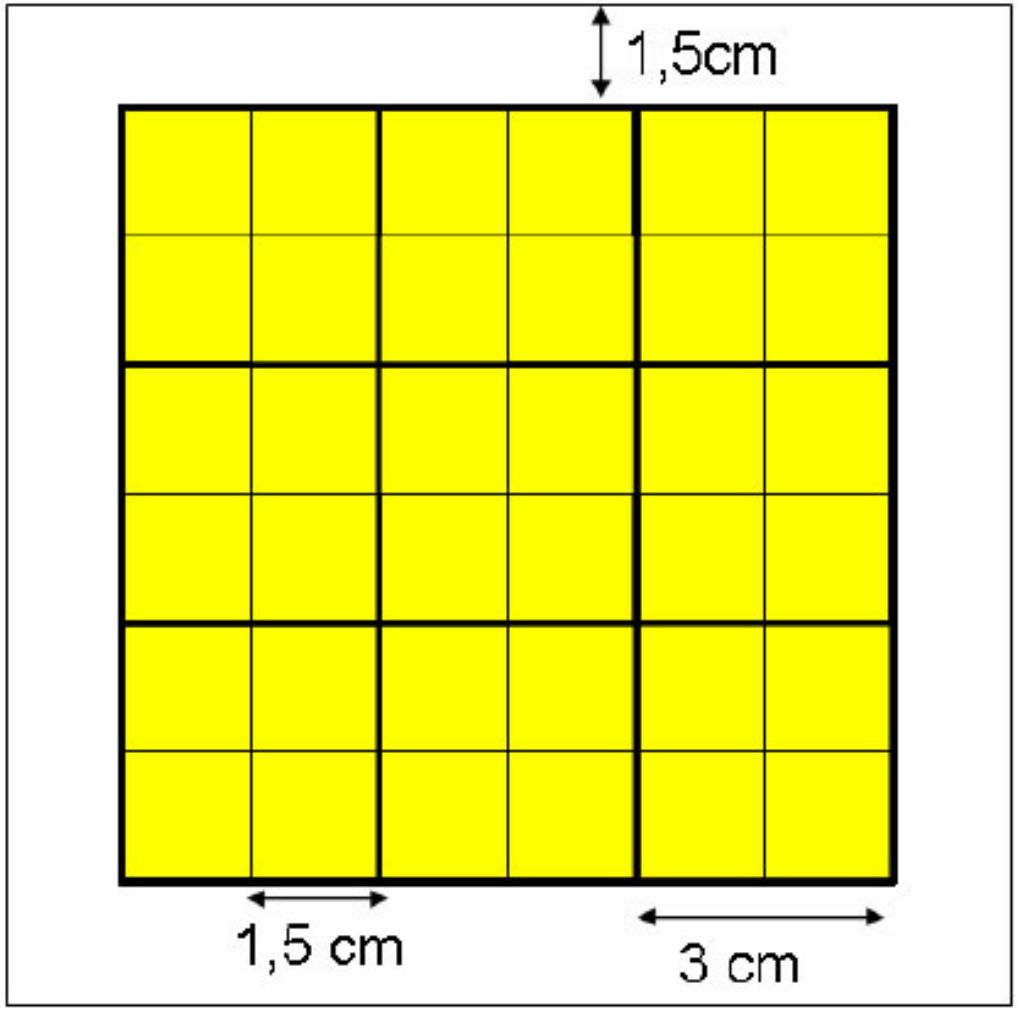
A flat image is acquired.

The analysis is performed by counting the defective pixel.

Tolerance: depending on manufacturer limits

DR: Uniformity

Purpose: The uniformity test is performed for testing the flat-field correction implemented in a digital system, by evaluating a uniform flat image over the entire area of the detector.



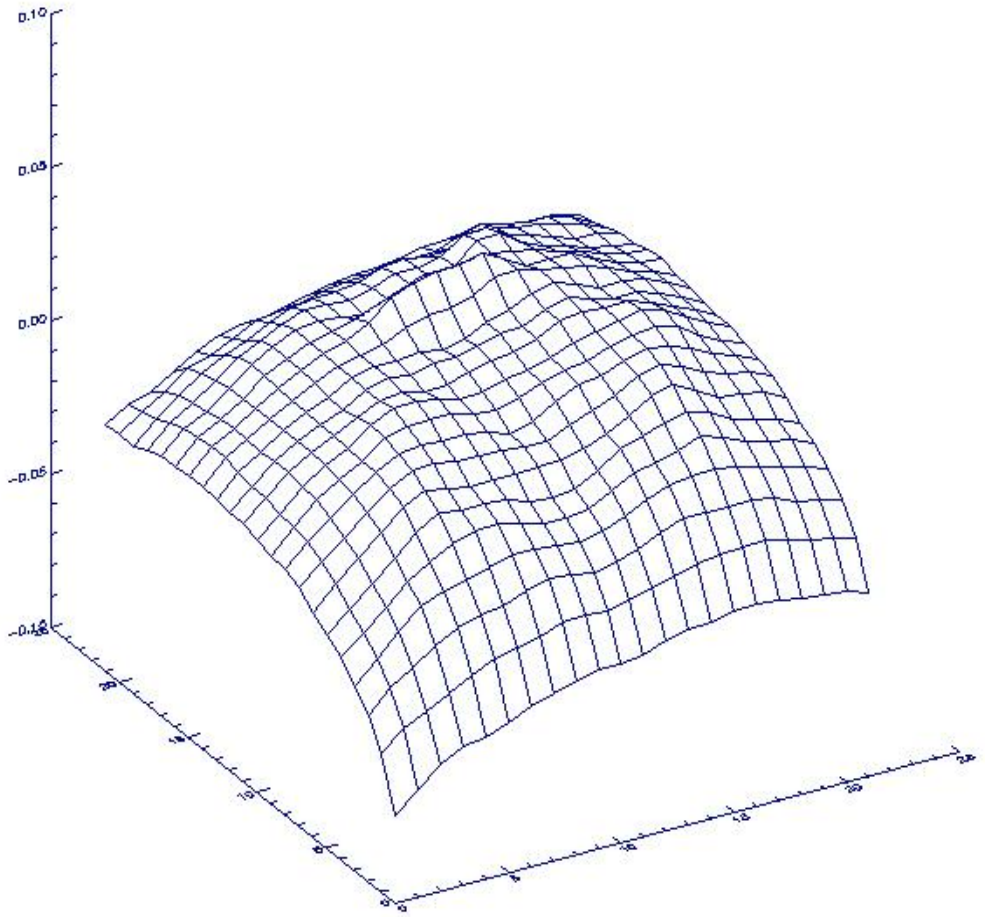
DR: Uniformity

Test	**Tolerance**
Local Signal	< 4%
Global Signal	< 8%
Local SNR	< 8%
Global SNR	< 20%

Local signal (or **SNR**) nonuniformity is evaluated as the mean signal intensity (or SNR) difference between the considered ROI and the average of the eight-neigborhood ROIs.

Global signal (or **SNR**) nonuniformity is evaluated as the difference between the maximum and the minimum mean signal intensity (or SNR) founded in all the ROIs

DR: Uniformity



Bad result due to an incorrect exposure
(distance focus-detector too small)

DR: Lag (for evaluating the artifacts due to previous exposures to the detector)

Additive lag

- an image acquired with a test phantom
- a non-irradiated image.

The additive lag is then calculated as the difference between the mean signal values of two ROIs on the non-irradiated image (one outside and one within the region of the test phantom), normalized by the mean signal value of the ROI positioned outside the phantom on the irradiated image.

Multiplicative lag

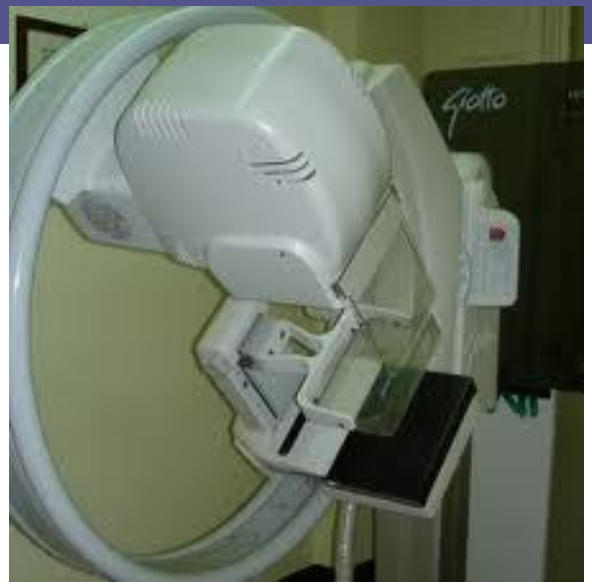
- one image acquired with a test phantom (image2),
- two uniform images with no phantom, one acquired before (image1), and one after the irradiated test image (image3).

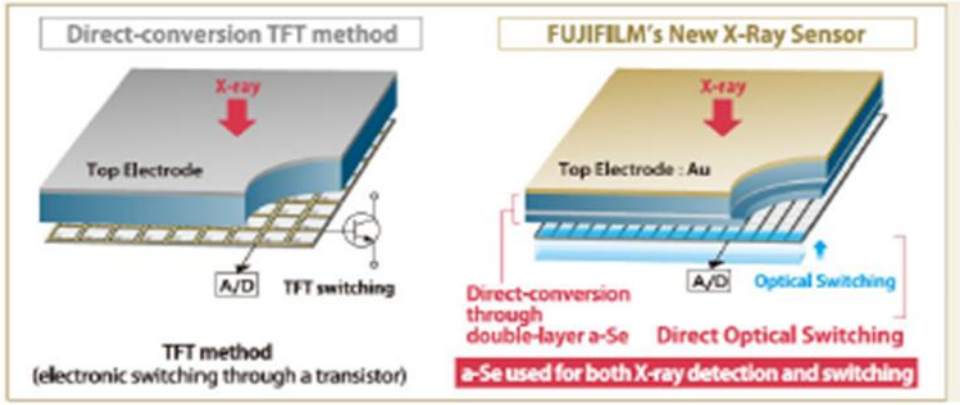
Two ROIs are needed: one positioned within the phantom area (ROI1) and one outside the phantom (ROI2). The multiplicative lag is then determined as:

$$\left| \frac{(\text{image1}_{\text{ROI1}} - \text{image1}_{\text{ROI2}}) - (\text{image3}_{\text{ROI1}} - \text{image3}_{\text{ROI2}})}{(\text{image1}_{\text{ROI2}} + \text{image3}_{\text{ROI2}}) \cdot 0.5} \right|.$$

Mammography

Flat panel: Direct conversion (a-Se) or Indirect Conversion (CsI + a-Si)





New detector - FujiFilm

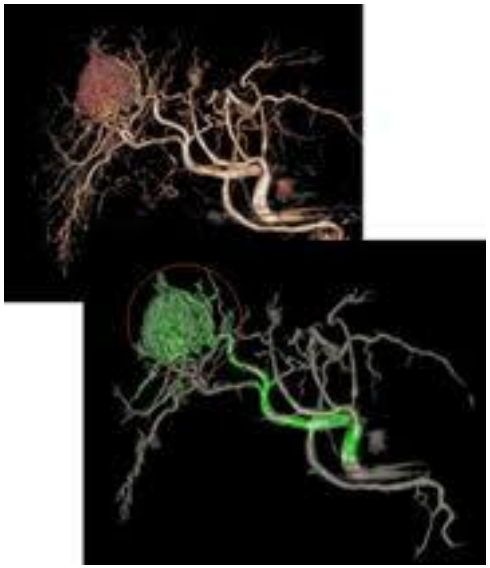
Sectra Microdose: single photon counting detector

(Scanning with thin x-ray fan-beam)

QC protocols

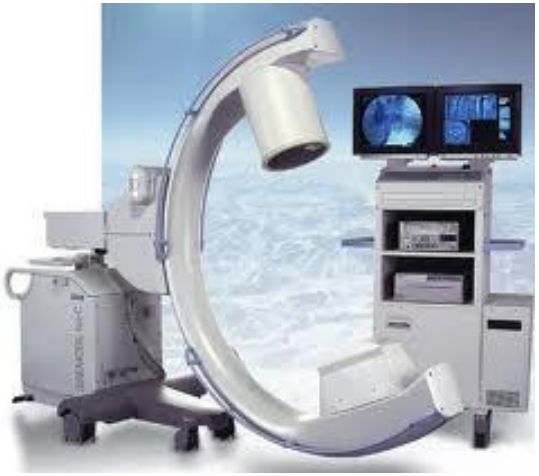
Interventional Procedures

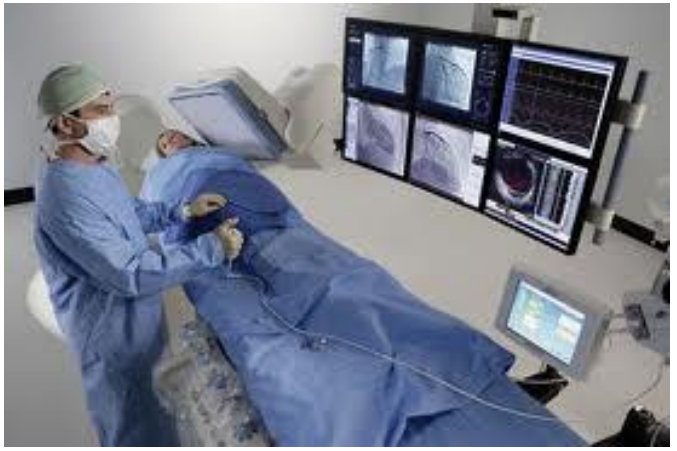
Interventional Radiology and Neuroradiology (vascular, oncologic, hepatobiliary, gynecological, kidney disease - disorders of the blood vessels of the brain, spine, head and neck)



Cardiology (treatment of structural heart disease (PTCA*), elettrophysiology (PM) …..)

*percutaneous transluminal coronary angiolplasty





Interventional Radiology, Neuroradiology and Cardiology

In flat panel for vascular and interventional radiology, neuroradiology and cardiology it is not always possible exporting DICOM for processing images.

DICOM Standard and Working Group 28

To serve as the integrator for all AAPM activities related to DICOM to develop or consult on change proposals and supplements requiring detailed expertise on physics and/or the needs and work of medical physicists. To serve as a liaison body to facilitate including data relevant to the physics community in DICOM objects. Collaborate with IEC on the new Work Item Proposals.

Detector dose indicator

This parameter is essential to monitor the patient dose and to avoid the risk of useless overexposure.

Quality Control

detector dose indicator calibration

(AEC calibration)

Quality Assurance (optimization)

establish the optimum range for the detector dose indicator

Film characteristic curve

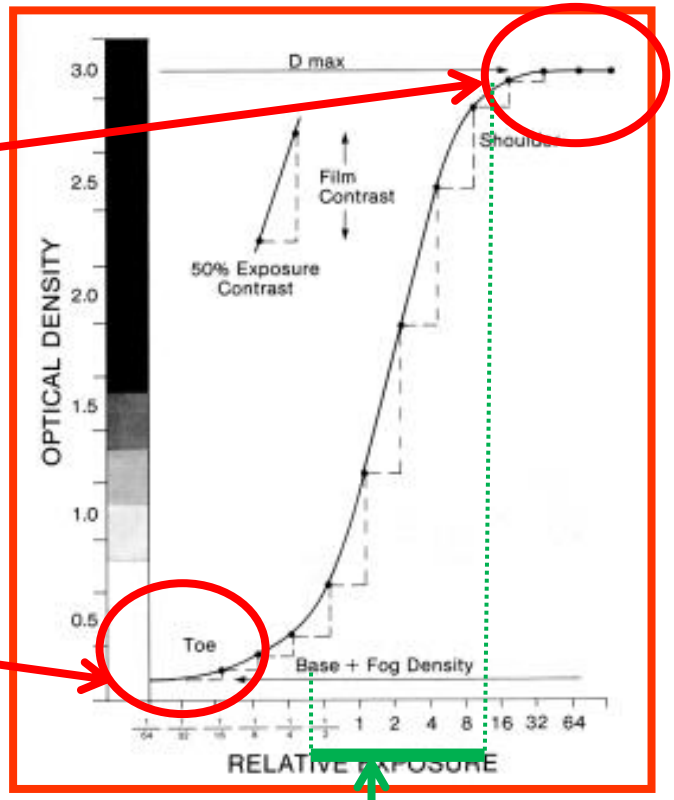
Plots of **film** density versus the log of exposure

Shoulder: dose too high

Linear or «straight-line" portion

Toe: dose too low

Dynamic range



Practical consequences

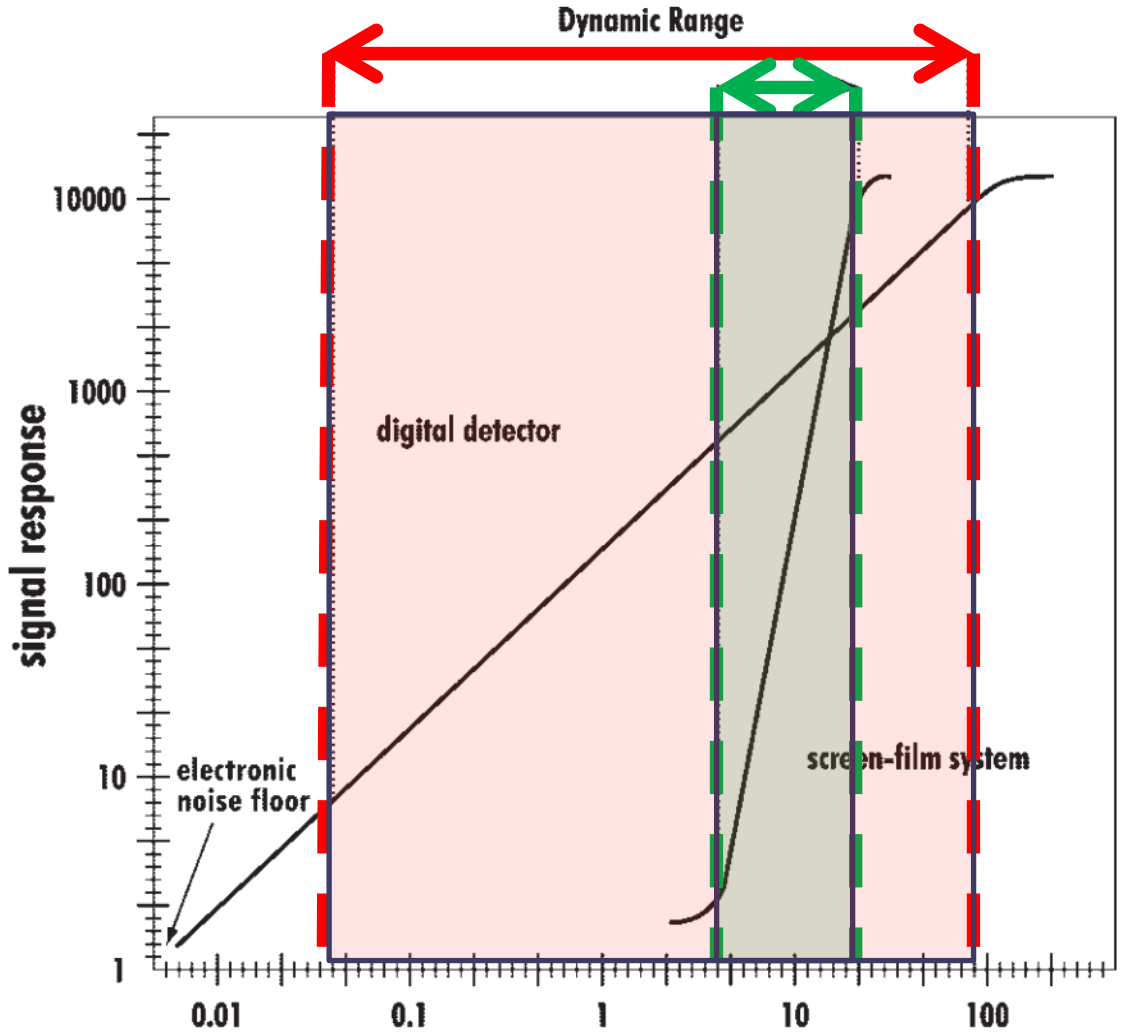
Screen-film imaging requires matching the dynamic range of the image receptor system to the range of the input signal

If input signal is too low, the film appears “White” (the image can not be used and another exposure is required)

If input signal is too high, the film appears “black” (the image can not be used and another exposure is required)

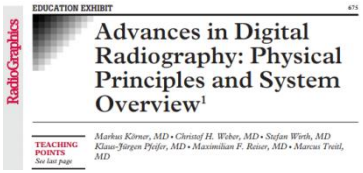
Both under-exposure and over-exposure require repeating the radiological procedure

Digital detector characteristic curve



Digital detector

Screen - film



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Digital detector characteristic curve

Digital detector offers

A WIDER DYNAMIC RANGE

compared with screen-film system .

Furthermore, post processing software are applied.

In digital radiology the grey levels of an image are normalized and the brightness of an image is independent of the mean absorbed dose in the imaging device.

Practical consequences

Considering grey levels, the digital images are never inadequate but

IMAGE QUALITY IS DEPENING ON ABSORBED DOSE

If the dose incident on the detector is too low, a poor image quality is produced (noise too high!).

If the dose incident on the detector is too high, a good image quality is produced (but the dose to the patient is too high)

CR: Detector dose indicator definition

Different for each manufacturer

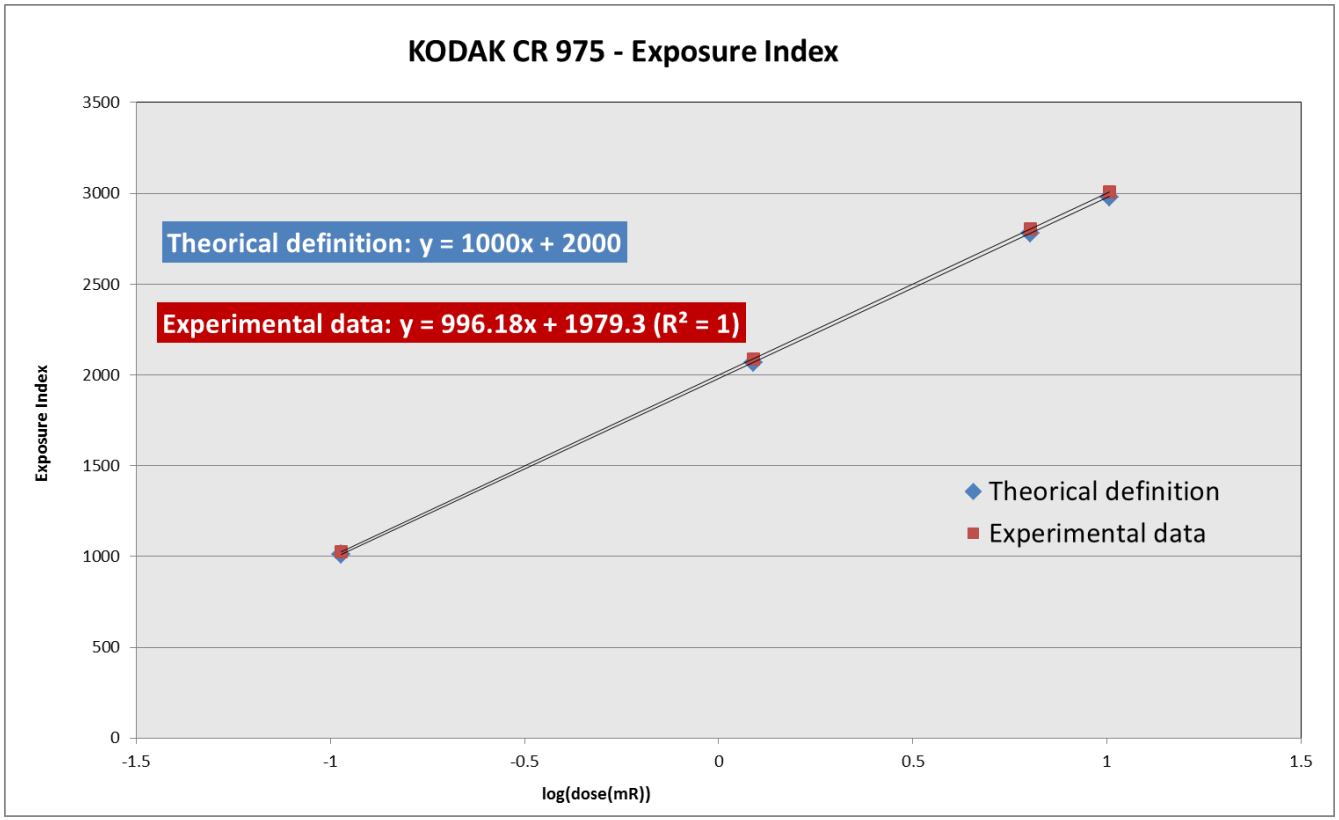
Three examples:

Kodak	Exposure index
Fuji	Sensitivity number
Agfa	LgM

KODAK: Exposure Index

EI = 1000·log10(dose(mR)) + 2000

The parameter is depending only on the dose incident on the plate and not on the selected post-processing software



Speed 200

(~ 0.5 mR)

↓

EI ~ 1700

AGFA: LgM

LgM parameter is defined as a function of SAL (Scan Average Level, mean digital value of an image) as:

$$\mathbf{LgM = 3.2768 - \log10[(4095/SAL)^2]}$$

To relate LgM to the dose, it is necessary to study the relationship between SAL and dose, which is

<u>depending on Speed Class</u>

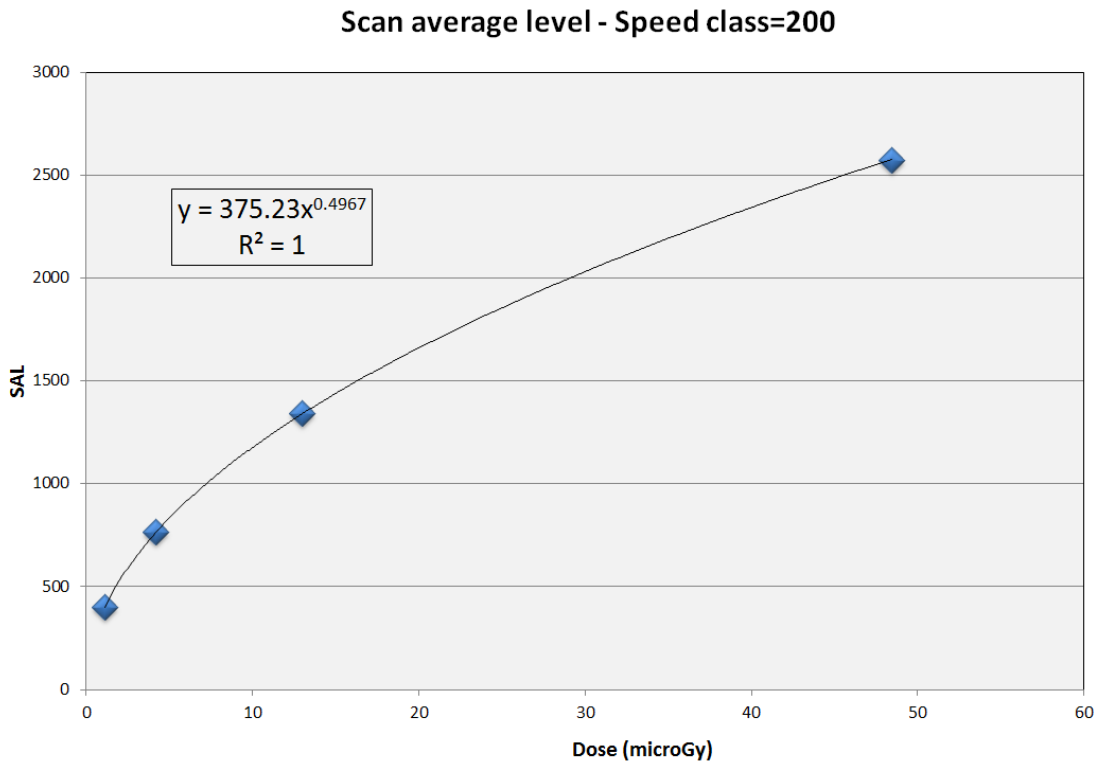
Exposure Parameter: 1.5 mm Cu; 75 kV; 30 mAs		
Exposure Class	SAL	LgM
50	797	1.84
100	1131	2.10
200	1609	2.43
400	2288	2.72
800	3240	3.05

AGFA: LgM

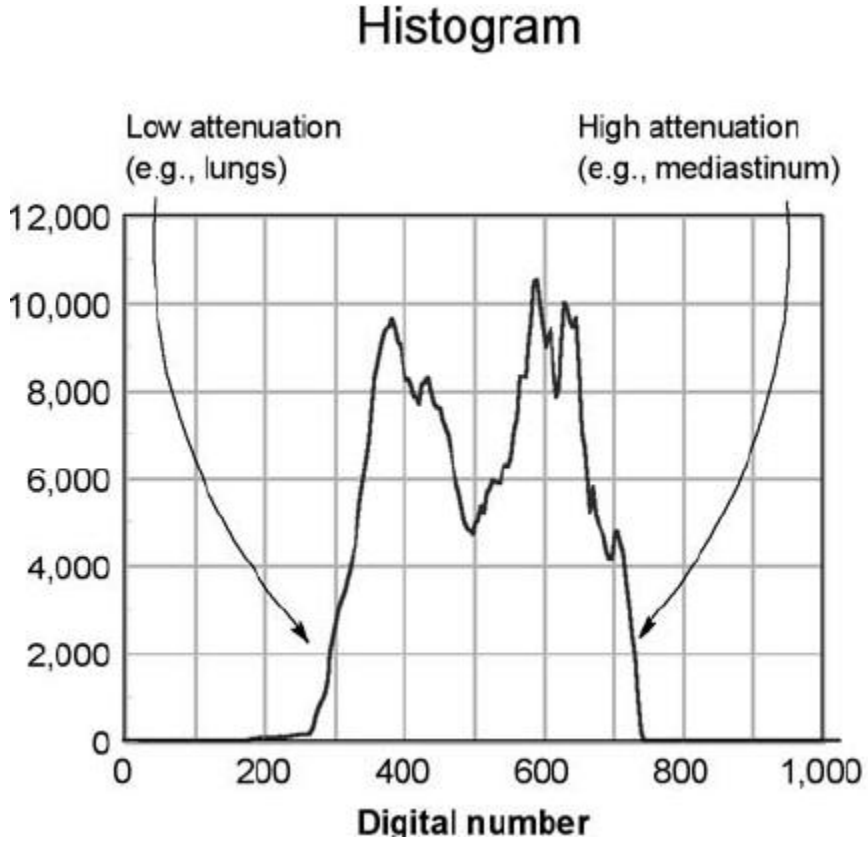
For AGFA system there is a square root relationship between SAL values and dose.

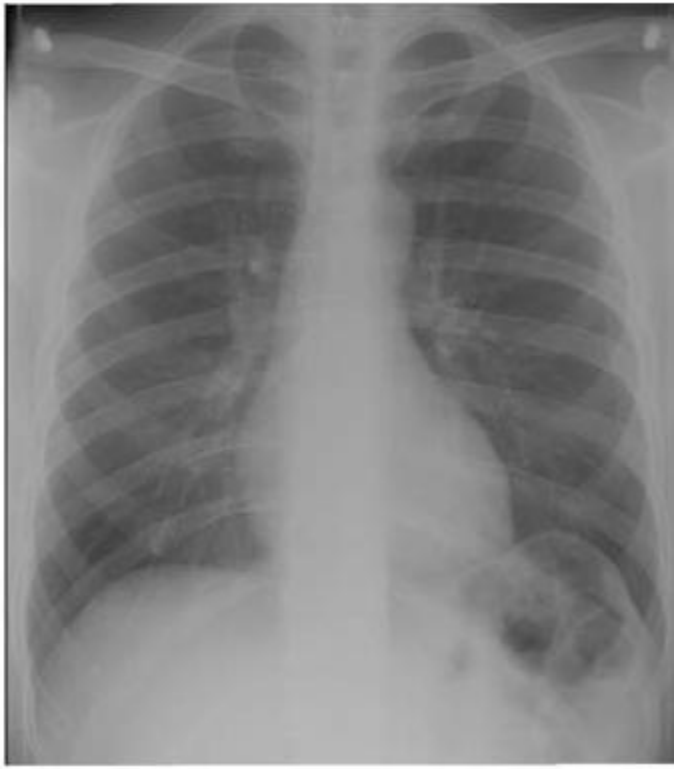
The parameters are depending on:

- speed class
- calibration condition
- type of the plate.



Fuji: Histogram Analysis



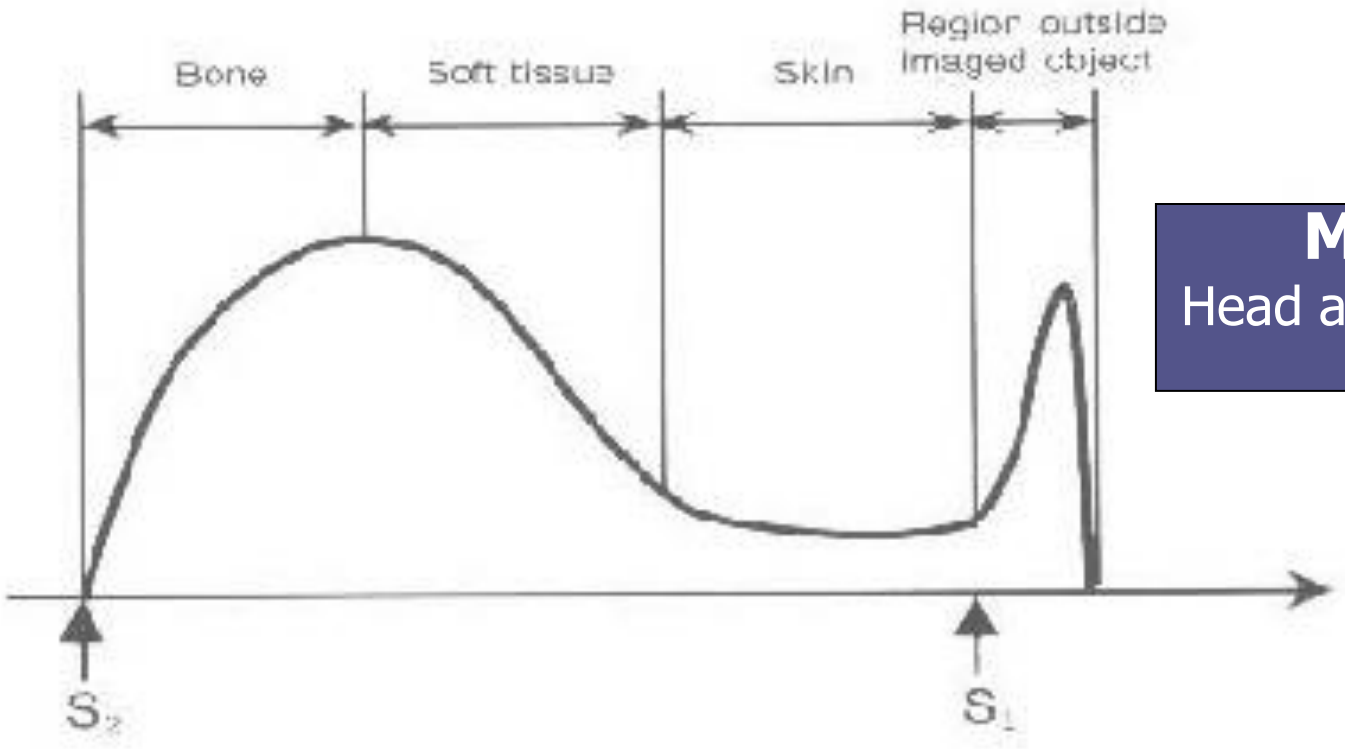


x-coordinate: image digital values

y-coordinate: number of pixel which have the digital value in the same range.

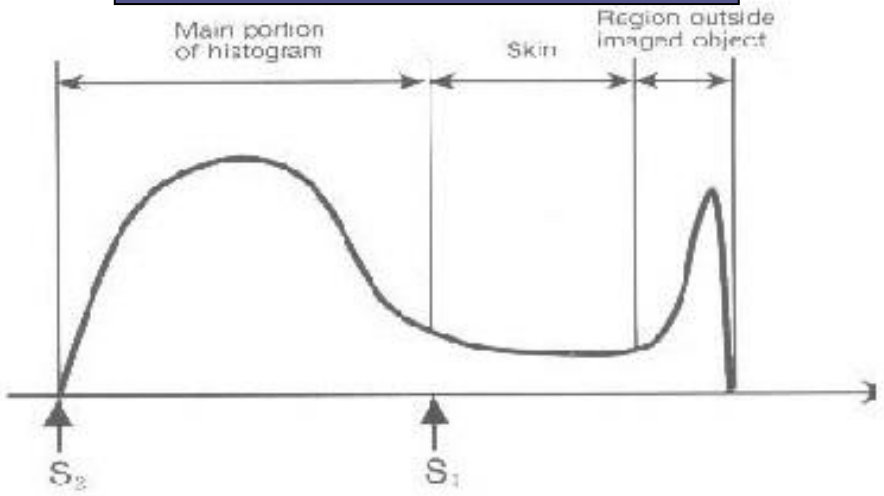
Fuji: Histogram Analysis

5 different mode of histogram Analysis are available

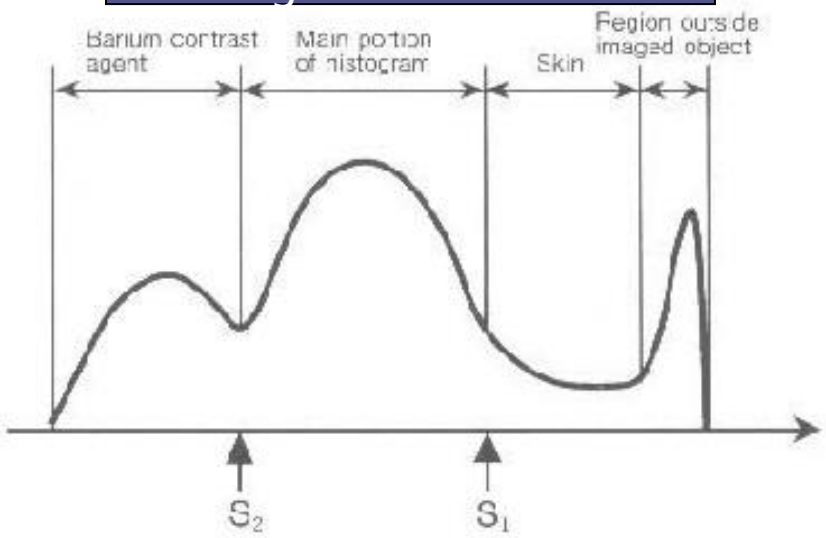


MODE A
Head and extremities

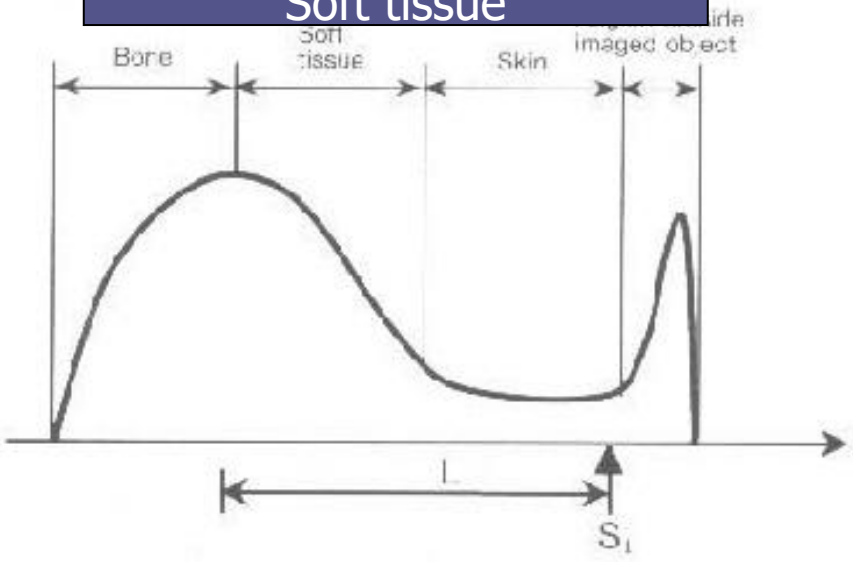
Mode B
Chest and abdomen



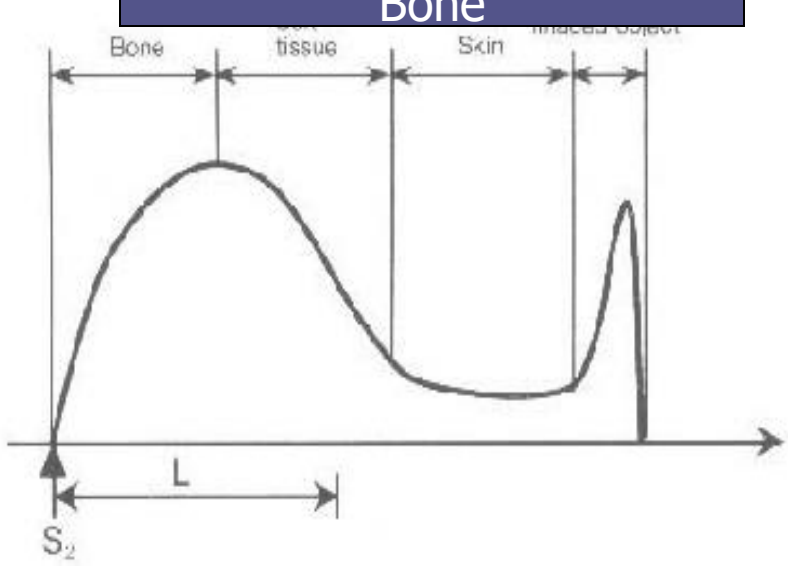
Mode C
Investigation with contrast

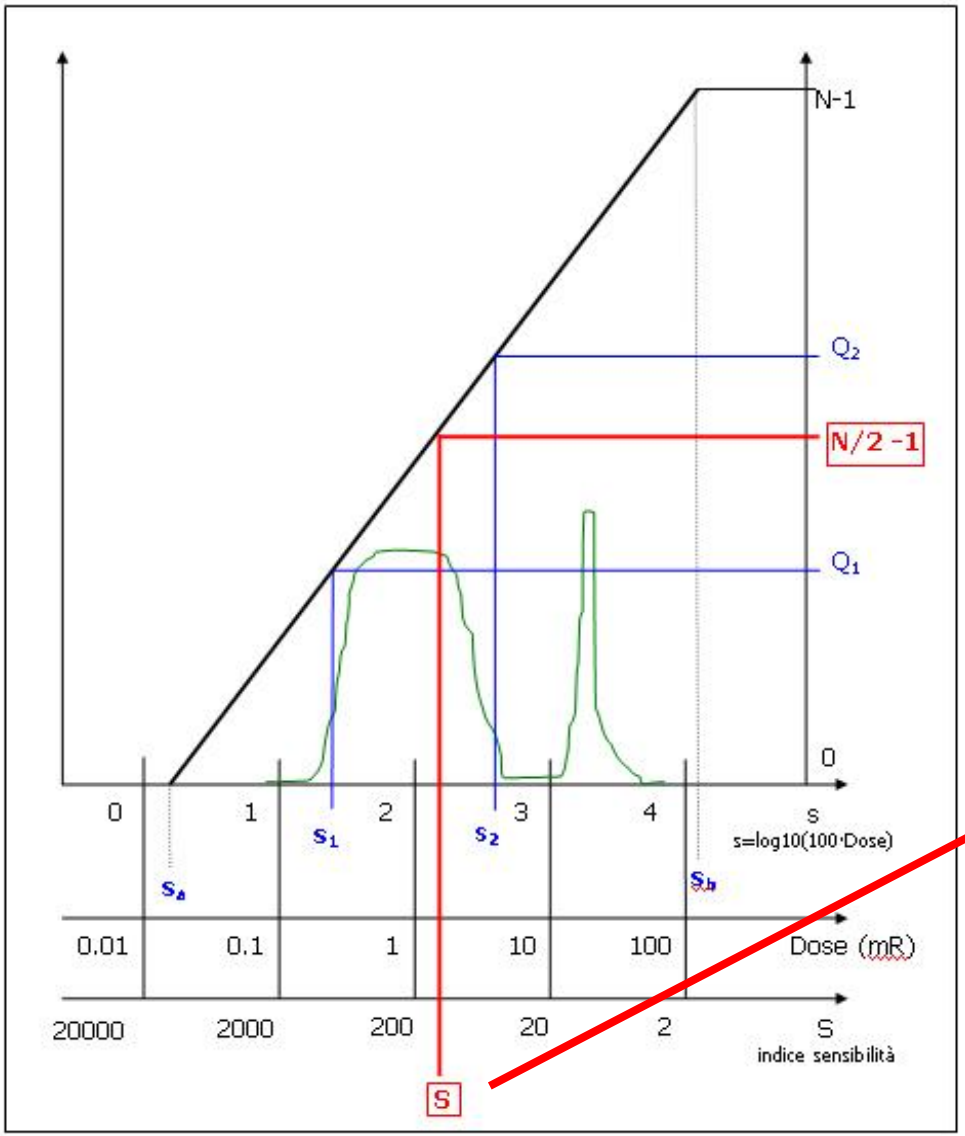


Mode D
Soft tissue



Mode F
Bone





SENSITIVITY INDEX

$S = 4 \cdot 10^{(4-s')}$

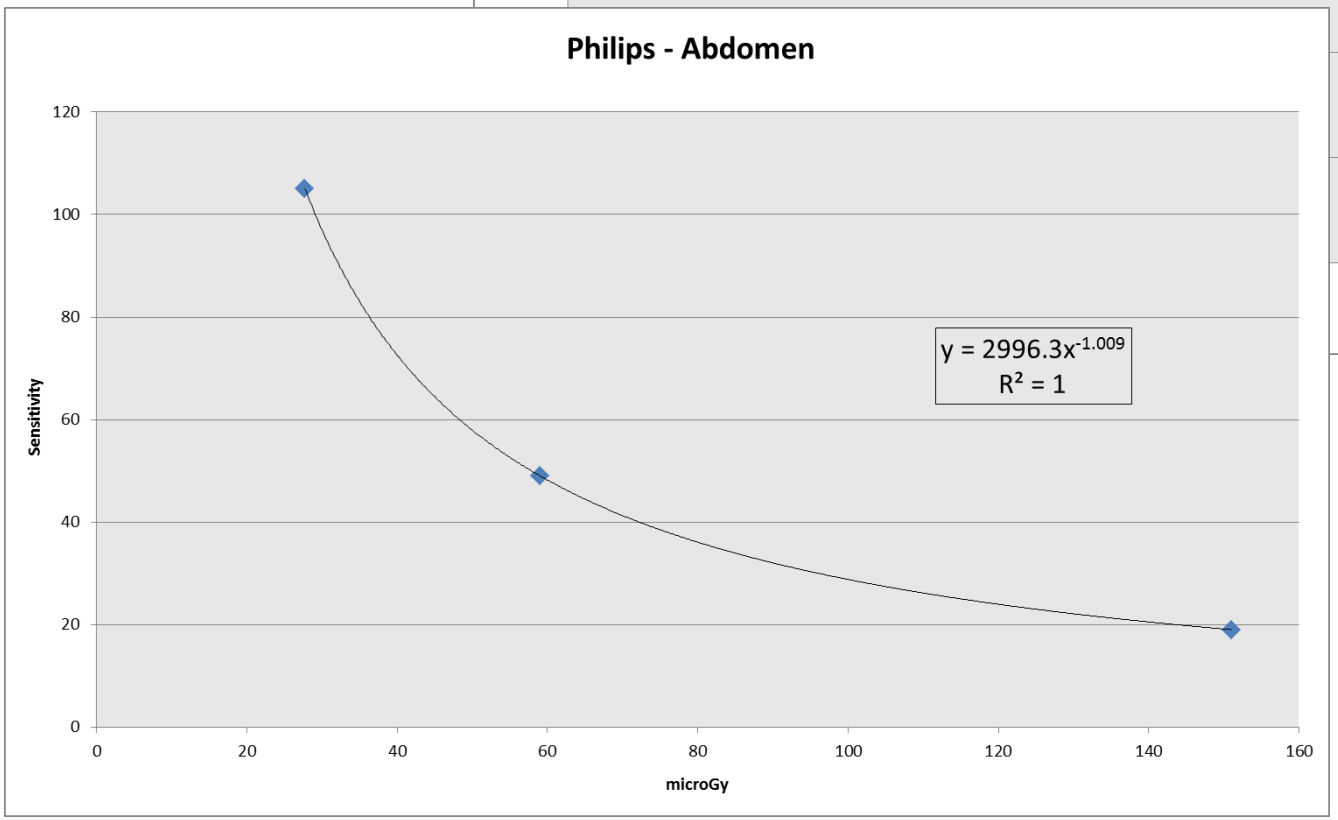
s' is related to the grey level N/2–1

LATITUDE INDEX $L = s_b - s_a$

s_a is related to grey level 0; s_b is related to grey level N-1

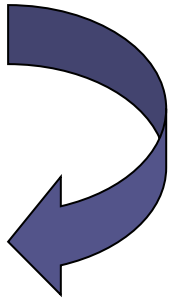
Fuji


Philips - Chest
600
500
400
300
Sensitivity
y = 16921x-1.065
R² = 1
50
60
70


Philips - Abdomen
120
100
80
60
40
20
0
Sensitivity
y = 2996.3x-1.009
R² = 1
0
20
40
60
80
100
120
140
160
microGy

CR: Detector dose indicator calibration

Different for each manufacturer



CR System	Filtration	kV	Delay*
Kodak	0.5 mm Cu + 1 mm Al	80 kV	15 minutes
Agfa	1.5 mm AL	75 kV	0
Fuji	none	80 kV	10 minutes

** Between exposure and reading*

CR: Detector dose indicator calibration

(Linearity and System transfer properties)

1) Expose the chamber at different mAs values

   (Select al least 4 mAs values, in order to obtain dose reading from 1 µGy to 50-100 µGy; 5 esposure for each mAs value, to verify X-Ray Tube)

2) Expose the plate (one for each cassette format)

3) Read the plate and record the detector dose indicator

These measurements should be used to establish the relationship between receptor dose and pixel value. (read the digital value in a ROI in the central area of the image [RAW DATA]; obtain the relationship between pixel value and receptor dose).

CR: Tolerance on detector dose indicator

According to "KCARE CR QA Protocol"

Calculate the dose incident on the plate using detector dose indicator.

Compare extimated dose value and measured dose value

<u>An example: KODAK</u>

$$EI_{Kodak} = 1000 \cdot \log_{10}(dose(mR)) + 2000$$

$$Dose_{Kodak} = 8.7 \cdot 10^{n} \quad \text{con } n = (EI - 2000)/1000$$

Tolerance: Measured dose ± 20%

DR: Detector dose indicators

An Example (GE Digital system: Definium 8000)

The systems shows three different values:

UDExp (Uncompensated Detector Exposure)

Estimated Exposure (μGy) to the detector behind the patient anatomy at 80 kv with no anti-scatter grid

CDExp (Compensated Detector Exposure)

Estimated Exposure (μGy) to the detector behind the patient anatomy, with the actual kV and use of anti-scatter grid

DEI (Detector Exposure Index)

A relative measure of exposure to the detector, as compared to expected exposure for a particul anatomy view.

AAPM REPORT NO. 116

An Exposure Indicator for Digital Radiography

Report of AAPM Task Group 116

July 2009

Image Quality: Geometrical aspect

Pixel size error

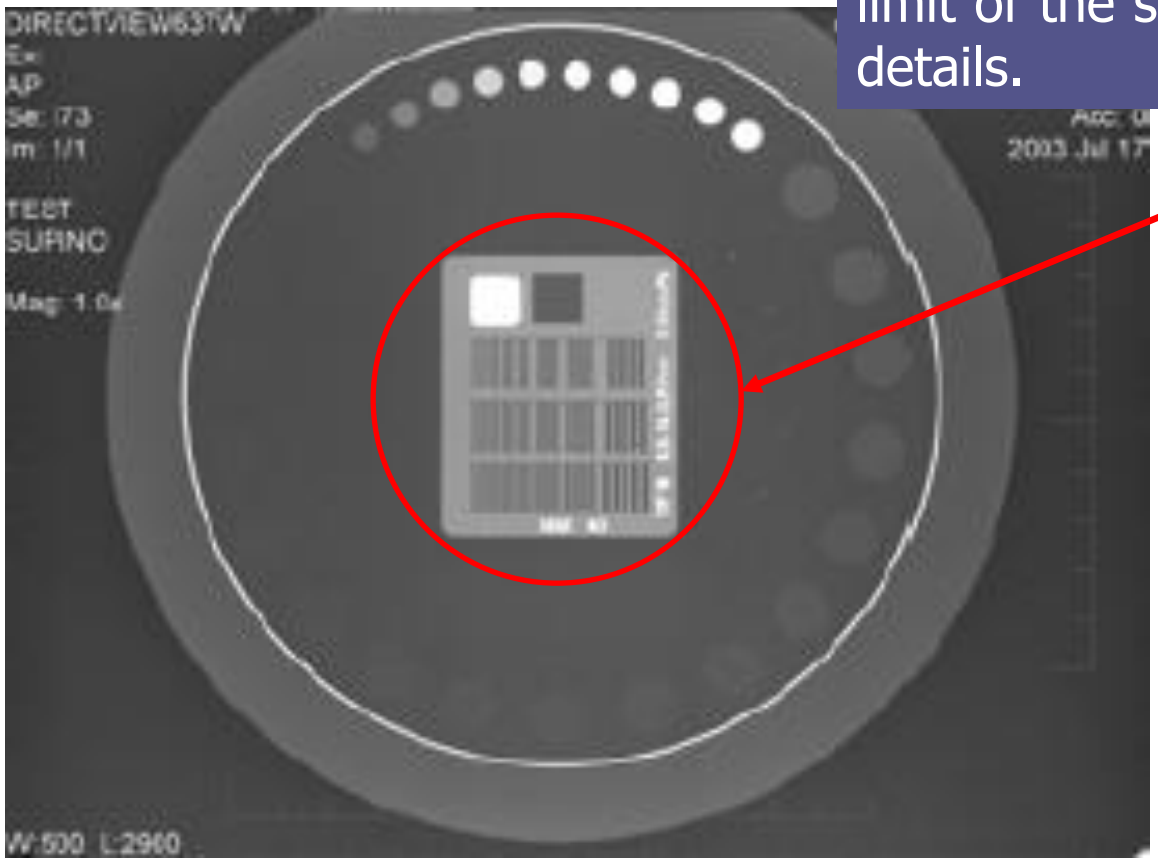
Aspect Ratio error

Image Quality Parameters

TestName	Test7
Date	07/03/2008
Cassette ID	9104167941
Pixel Size Error Fast(%)	0.7
Pixel Size Error Slow(%)	0.3
Aspect Ratio Error Left(%)	3.2
Aspect Ratio Error Middle(%)	0.2
Aspect Ratio Error Right(%)	-1.6
Aspect Ratio Error Average(%)	-0.3
Fast-Scan Speed Error(%)	0.41
Slow-Scan Speed Error(%)	0.04
Low-Exposure Response Error(CV)	67.2
Mid-Exposure Response Error(CV)	-4.9
High-Exposure Response Error(CV)	-27.9
Low-Exposure Noise(CV)	11.9
Mid-Exposure Noise(CV)	5
High-Exposure Noise(CV)	3.8
Fast-Scan MTF @ 50% Nyquist(%)	37.7
Fast-Scan MTF @ 95% Nyquist(%)	10.5
Slow-Scan MTF @ 50% Nyquist(%)	38.5
Slow-Scan MTF @ 95% Nyquist(%)	14.9

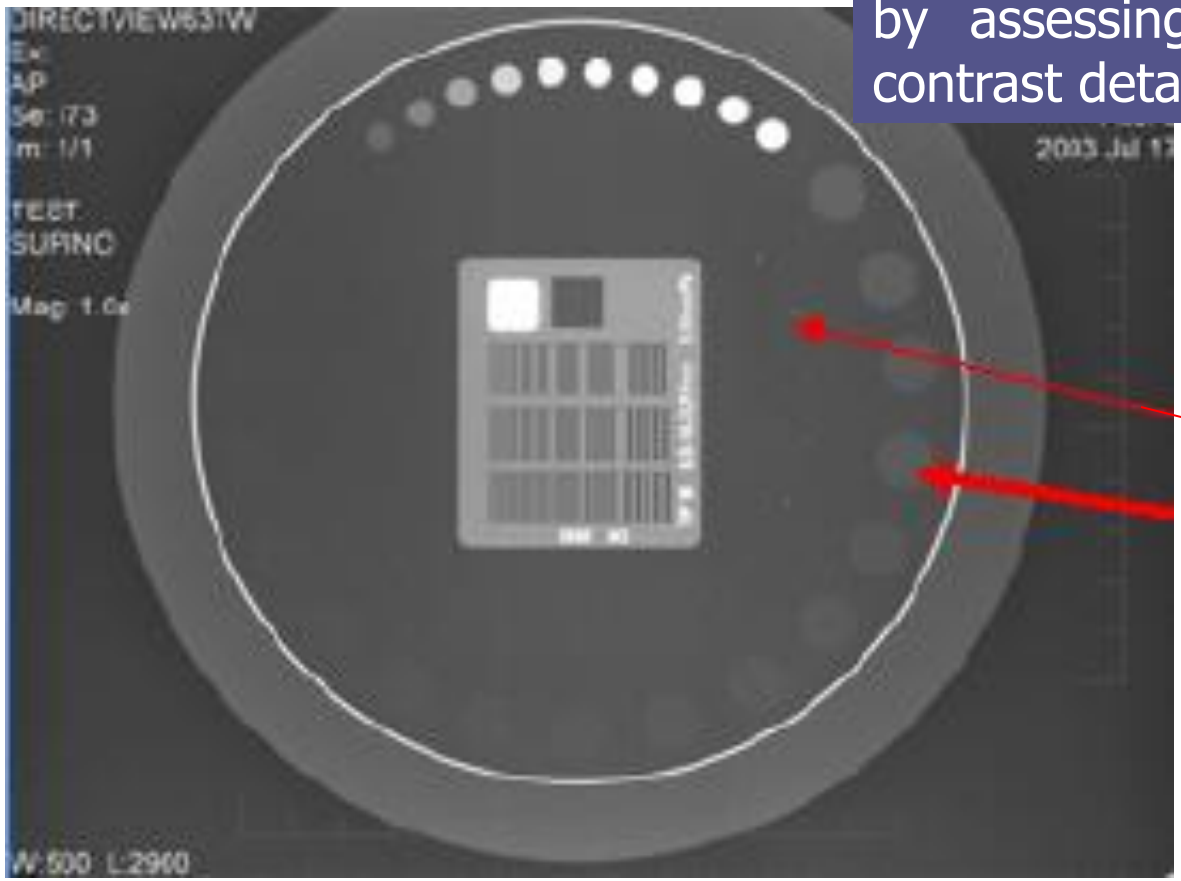
Spatial resolution

Purpose: To test the high contrast limit of the systems ability to resolve details.



Low Contrast resolution

Purpose: To monitor image quality by assessing the visibility of low contrast details



0.5 mm spheres

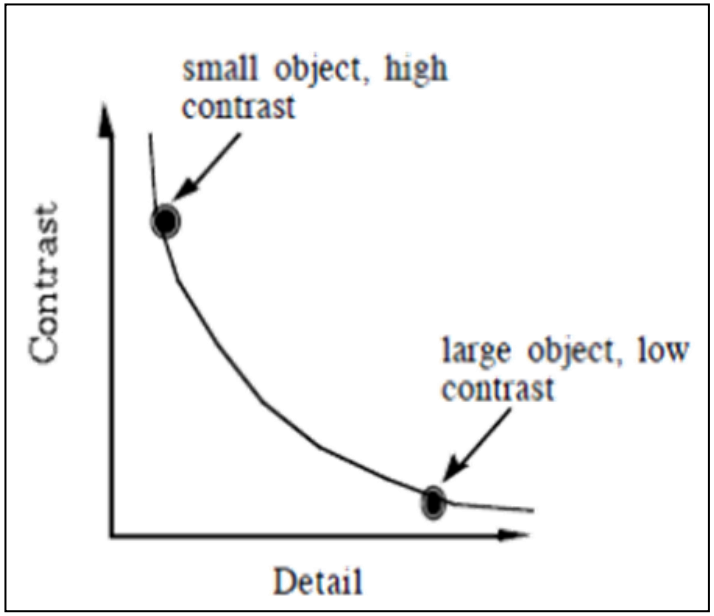
11 mm spheres

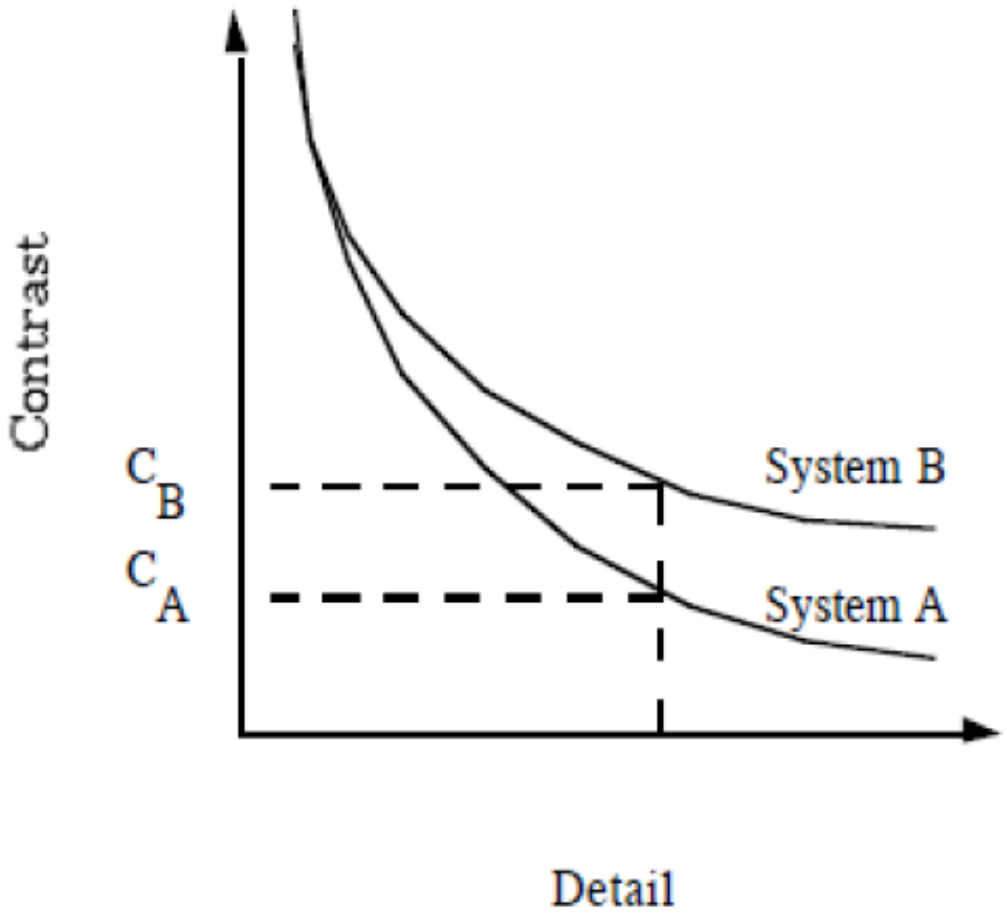
Contrast Detail Analysis

To provid a quantitative measure of image quality (IQ), Low Contrast Detectability (LCD) is a fundamental parameter to be taken into account.

The routine assessment and control of IQ is often evaluated in terms of threshold contrast visibility of details varying in diameter and contrast.

Contrast detail curves, displaying the minimum detected contrast for each detail diameter, are commonly used for reporting.



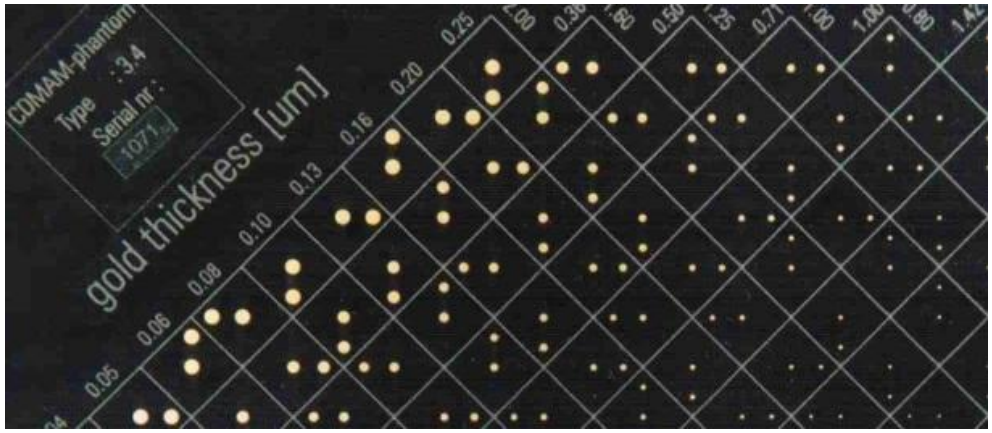


Considering the same detail, system A is able to detect a lower contrast compared with the system B

Contrast Detail Analysis

CD analysis is done using special phantoms (CDRAD, CDMAM..)

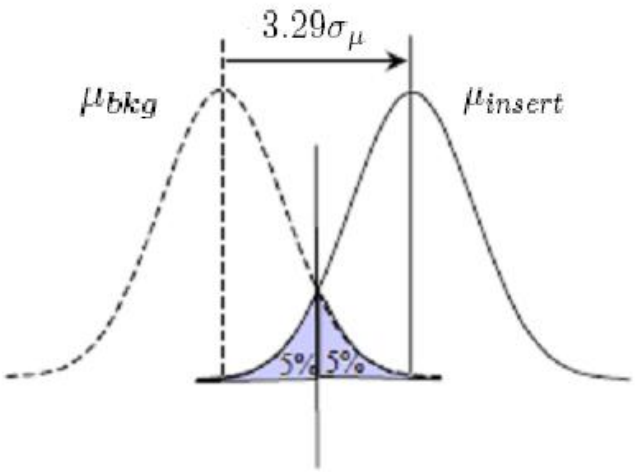
The phantoms were developed with the purpose of estimating the perception of details on a range of sizes and contrasts. Automatic methods have been developed to evaluate the visibility of the details



A Statistical Method of Defining Low Contrast Detectability

E.H. Chao, T.L. Toth, N.B. Bromberg, E.C. Williams, S.H. Fox, D.A. Carleton
GE Medical Systems, Milwaukee, WI
RSNA 2000

Considering several identical regions of interest (ROI) placed on a uniform background, each with a mean pixel value (PV), the standard deviation of these means (σ_μ) can be use to evaluate LCD (according to the Central Limit Theorem).



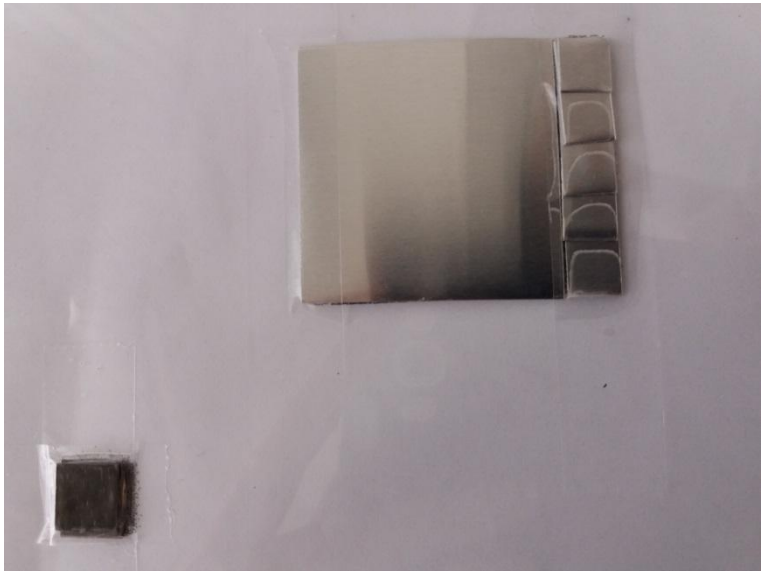
An insert inside a homogeneous background is detectable with a 95% confidence level if:

$$\mu_{insert} - \mu_{bkg} > 3.29 \times \sigma_\mu$$

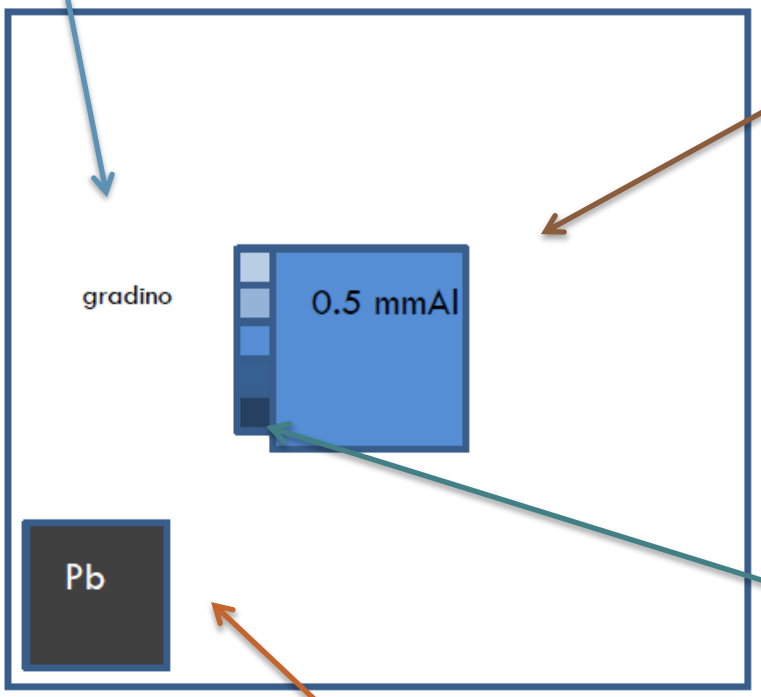
Working Group of AIFM (Italian Society of Medical Physics)

Proposal: The statistical method od defining low contrast detectability could be used not only for CT, but in angiography, conventional radiology, mammography mammografia, sistemi di diagnostica convenzionale)

NIPAR Phantom



A dedicated phantom allowing application of the outlined method for LCD evaluation was designed.



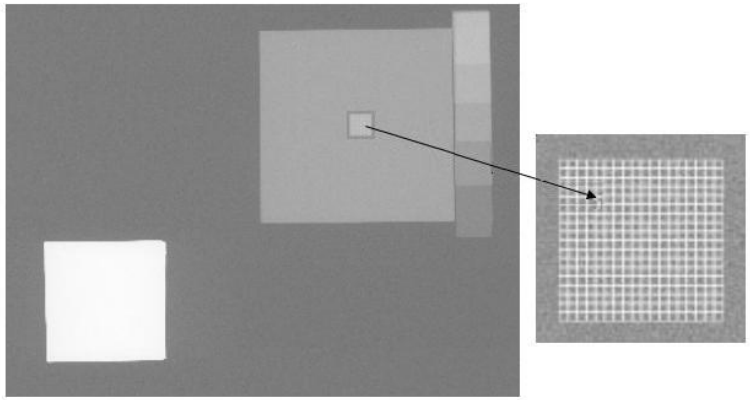
A central uniform aluminium region (4x4cm^2, 0.5 mm thick);

An aluminium step wedge, with increasing thicknesses from 0.25 to 1.00 mm (each step is 0.8x0.8cm^2).

A lead insert (1x1cm^2, 0.2 cm thick), in lateral position

A Matlab code for automated analysis of LCD test object images was developed

- A square ROI (typically 120 x 120 pixels) is placed in the center.
- For every insert dimension, this ROI is divided into a subROIs-matrix.
- For each subROI, the mean pixel value μ_i is calculated, along with the standard deviation σ_μ of these means



The low contrast threshold LC_{th} necessary to detect an insert was estimated by multiplying σ_μ by 3,29

Results in angiography