

A light blue silhouette of a city skyline, featuring various buildings and a prominent tower, serves as a background for the title.

Image Quality

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LTO Distributer Meeting,
York



Image Quality

- Introduction
 - Radiation imaging
 - Risk
 - Legal
- Image production
 - X-rays
 - Processing/Display



Image Quality

- Parameters
 - Contrast
 - Noise
 - Resolution
 - Uniformity
 - Artefacts
 - Distortion
 - Glare
 - Interference



Image Quality

- QA tests
 - Background
 - Level A/B
- Summary



Image Quality – Introduction

- Any diagnostic test requires some method of viewing inside the patient to answer a clinical question
- Performing any diagnostic test comes with risk (or cost)
- **The requirement is to answer the question (positive/negative) with the optimal risk/cost**



Image Quality – Risk

- Radiation can be used for imaging but comes with a risk
- Relatively, that risk is low, hence x-ray imaging is a well used and well studied technique
 - 46 million medical and dental examinations in UK in 2008
 - 90% of population dose from medical imaging
- Still want to maintain a risk/benefit balance



Image Quality – Legal

- Ionising Radiations Regulations 1999 (IRR 99)
- Ionising Radiations (Medical Exposures) Regulations 2000 (IRMER 2000)
- **As Low As Reasonably Practical**
- Optimisation, Justification, Limitation



Image Quality – Image Production

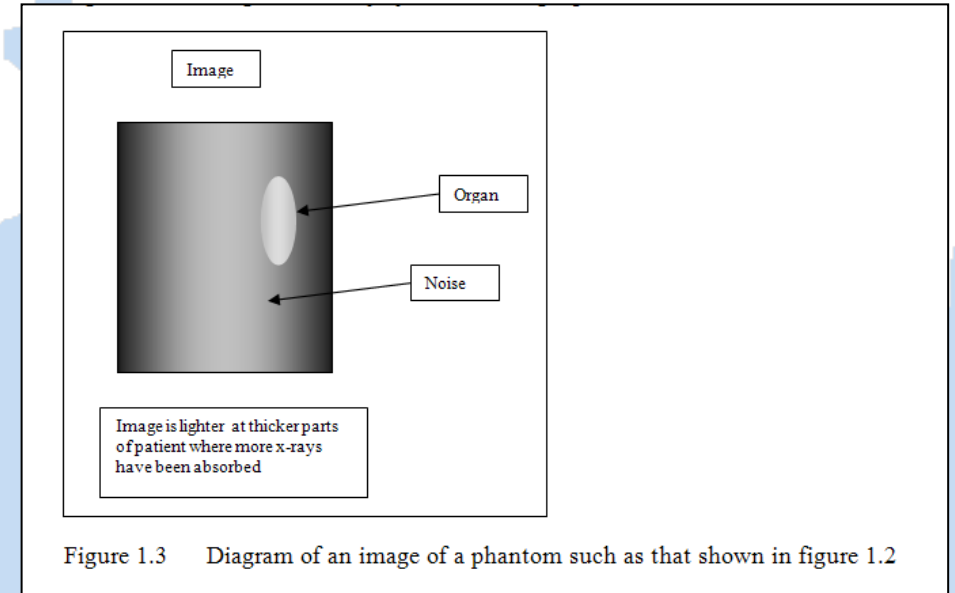
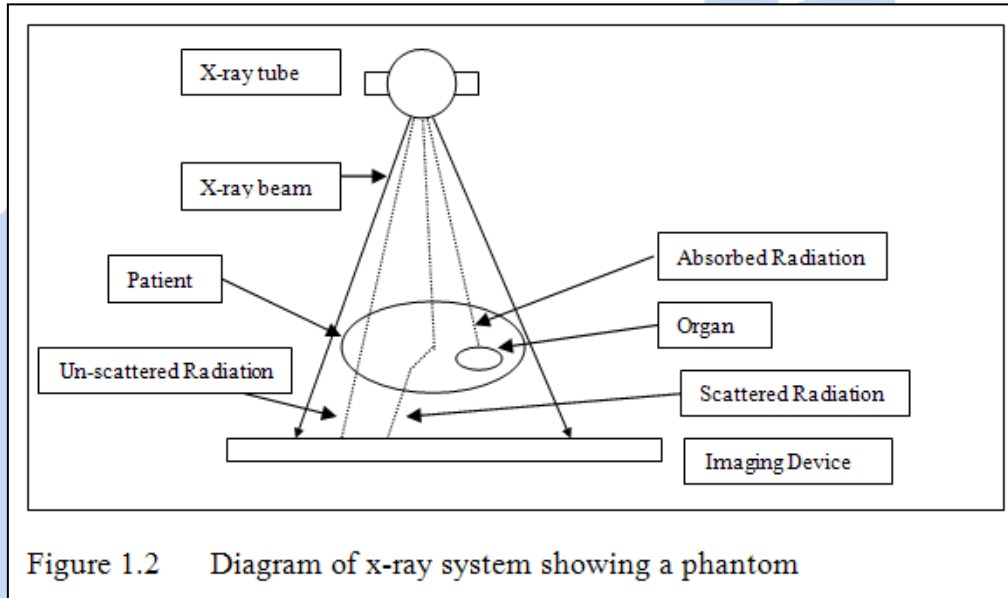


Image Quality – Image Production

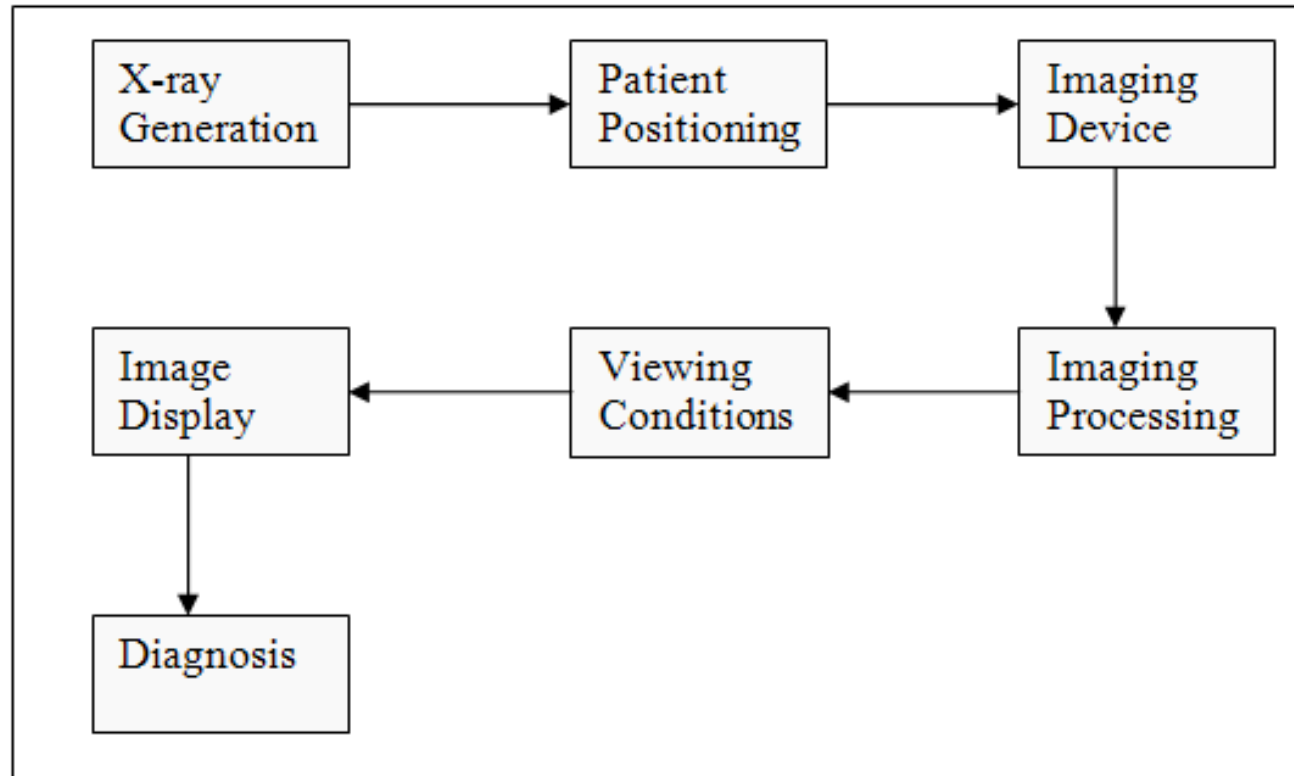


Figure 1.6 Box diagram illustrating the imaging chain

Image Quality – Image Production

- mAs (mA and s)
 - Number of photons
 - More photons reach detector
 - More photons absorbed in patient
 - More contrast
 - More dose
- kVp
- Filtration



Image Quality – Image Production

- mAs (mA and s)
- kVp
 - Energy of the photons
 - Higher kV, more likely to penetrate, less likely to be absorbed
- Filtration



Image Quality – Image Production

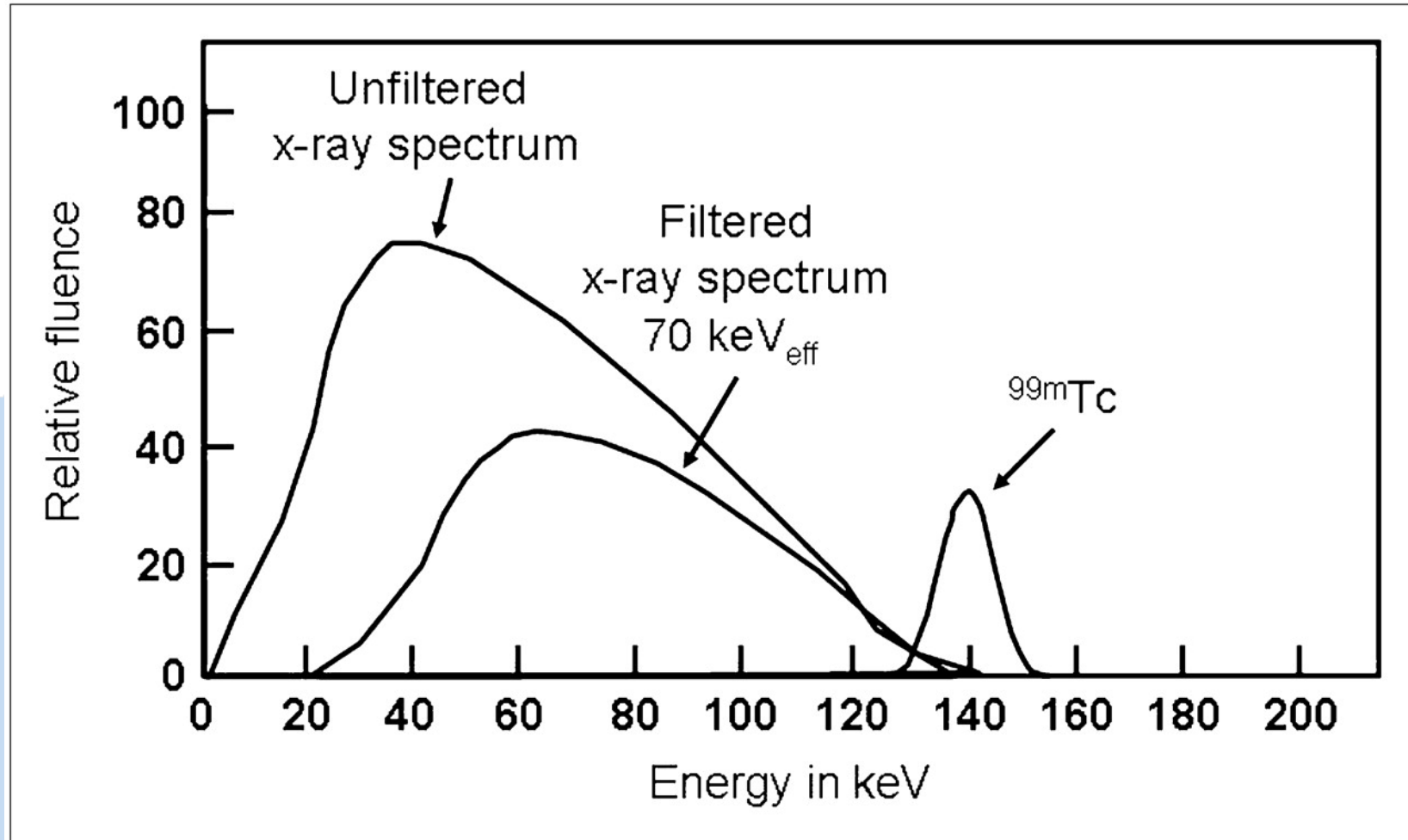


Image Quality – Image Production

- mAs (mA and s)
- kVp
- Filtration
 - Legal minimum of 2.5 mmAl equivalent (70 kVp+)



Image Quality – Image Production

- Processing and display
 - (IMO) A forgotten component of IQ

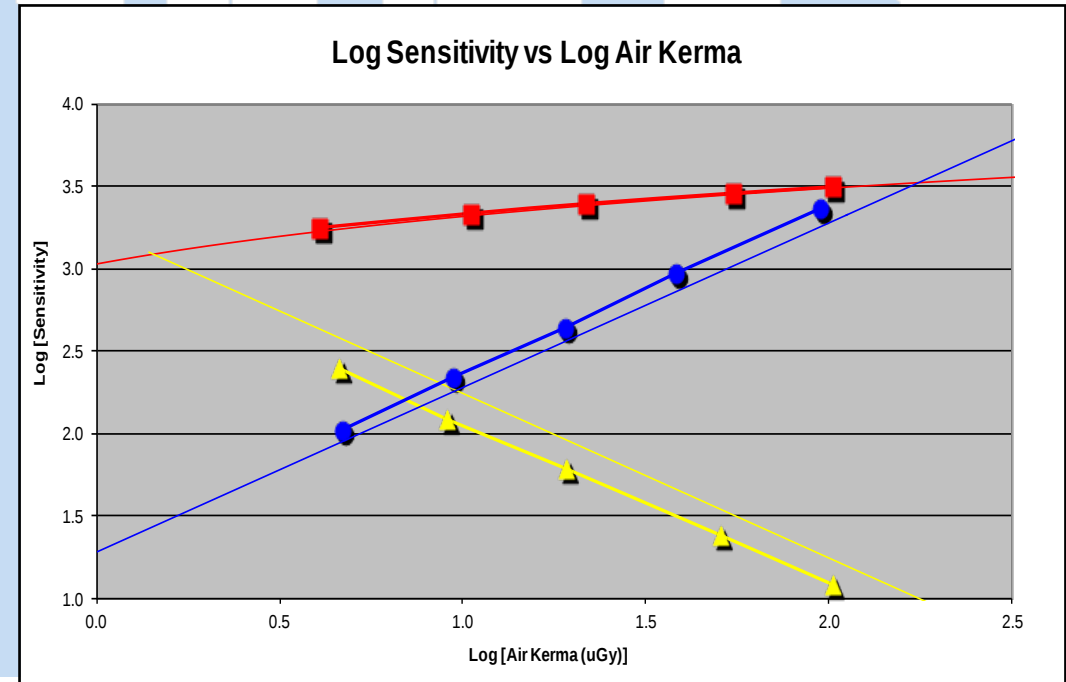
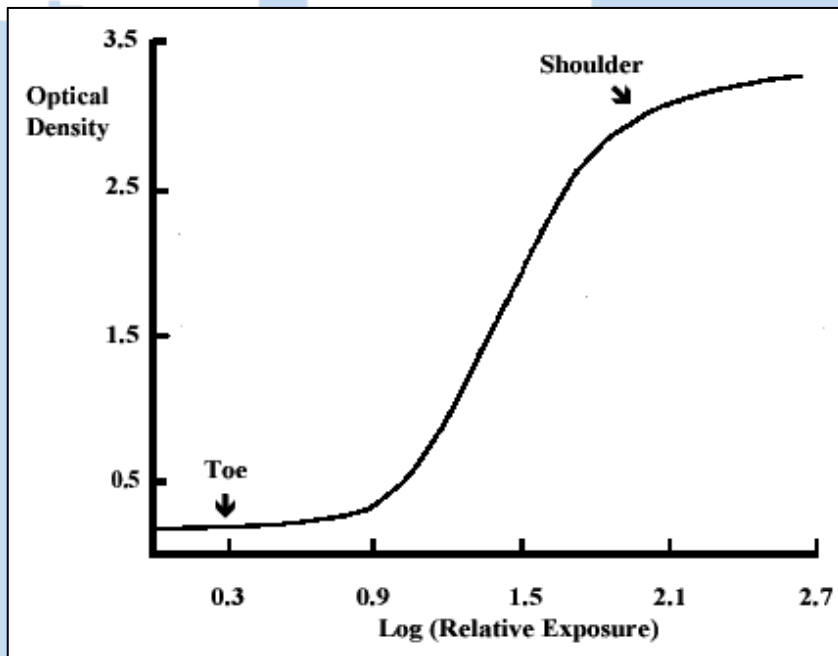
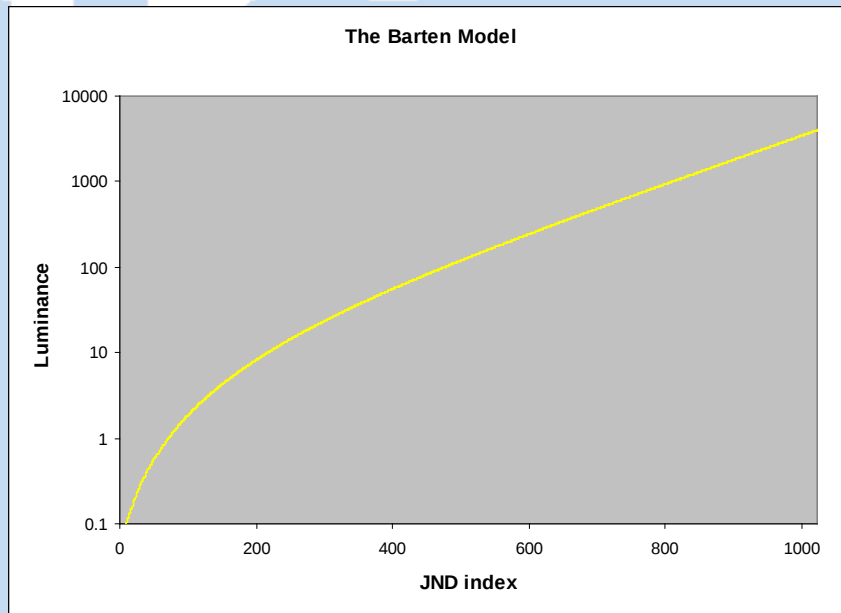


Image Quality – Image Production

- Image brightness needs to take into account the response to the human eye (GSDF)



$$\text{Log}_{10} L_j = \frac{a + c(\text{Log}_e j) + e(\text{Log}_e j)^2 + g(\text{Log}_e j)^3 + m(\text{Log}_e j)^4}{1 + b(\text{Log}_e j) + d(\text{Log}_e j)^2 + f(\text{Log}_e j)^3 + h(\text{Log}_e j)^4 + k(\text{Log}_e j)^5}$$

Image Quality – Contrast

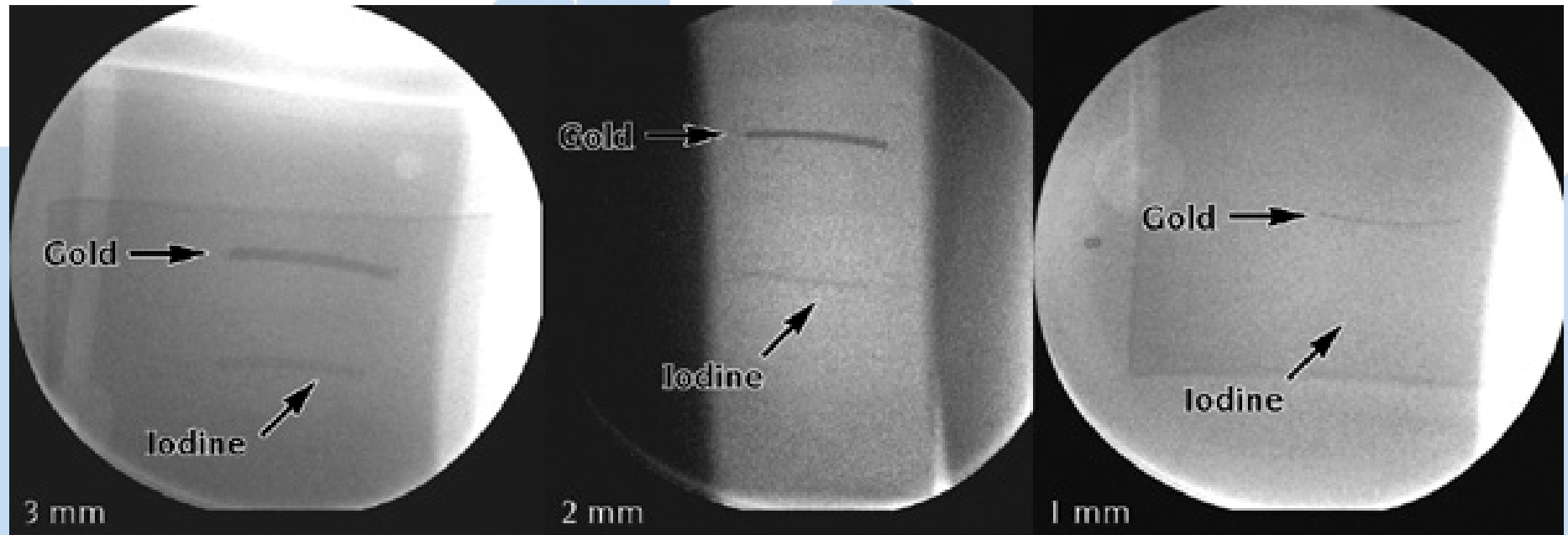


Image Quality – Contrast

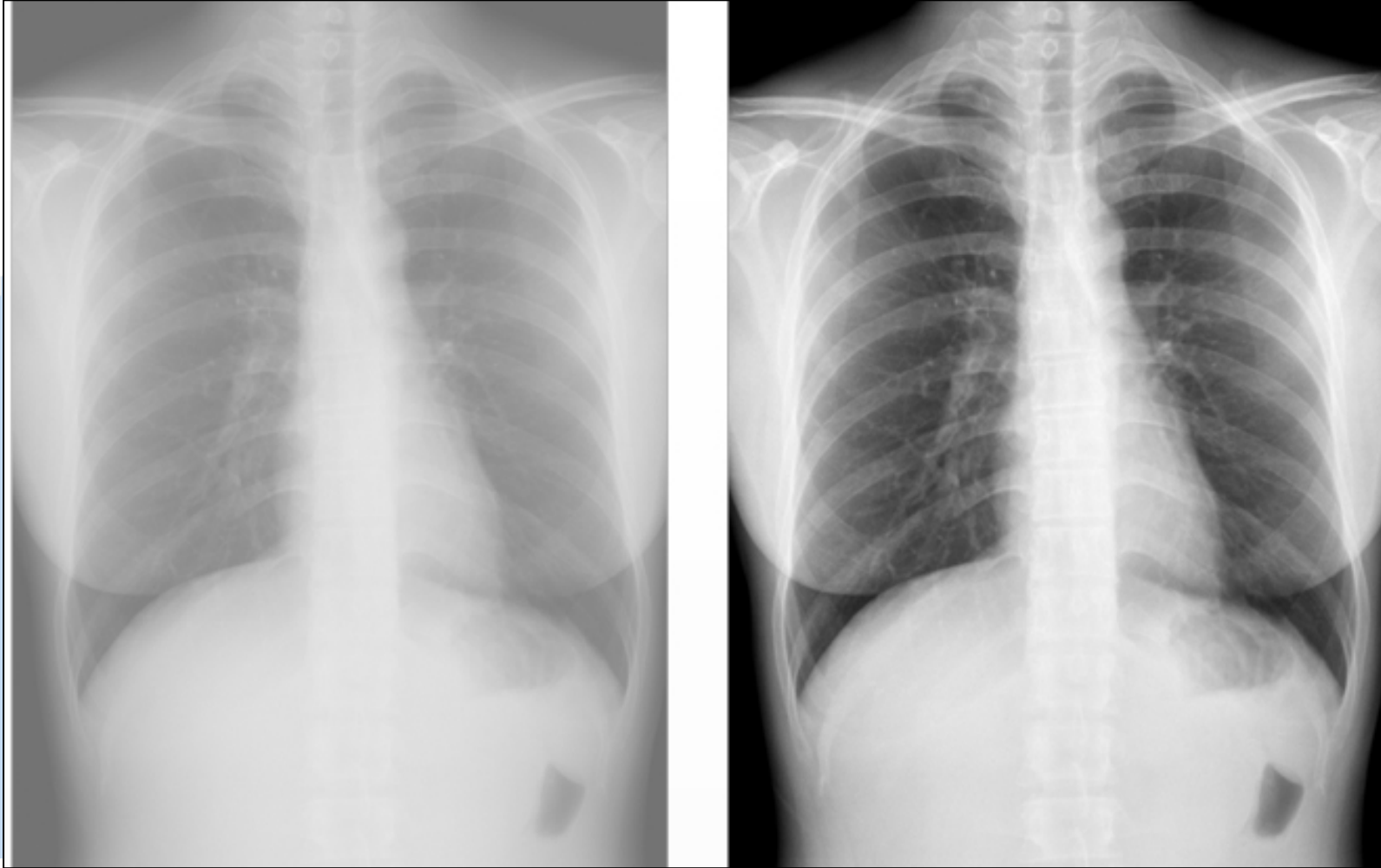


Image Quality – Contrast

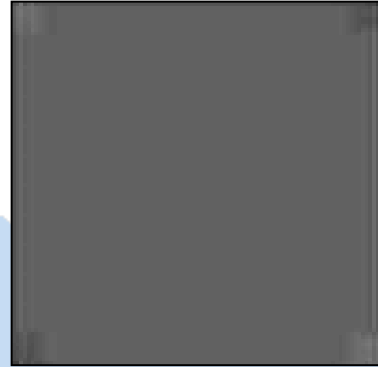
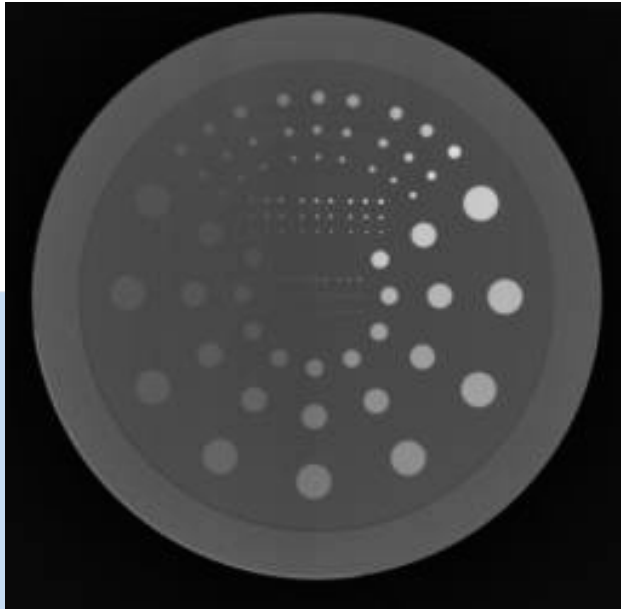
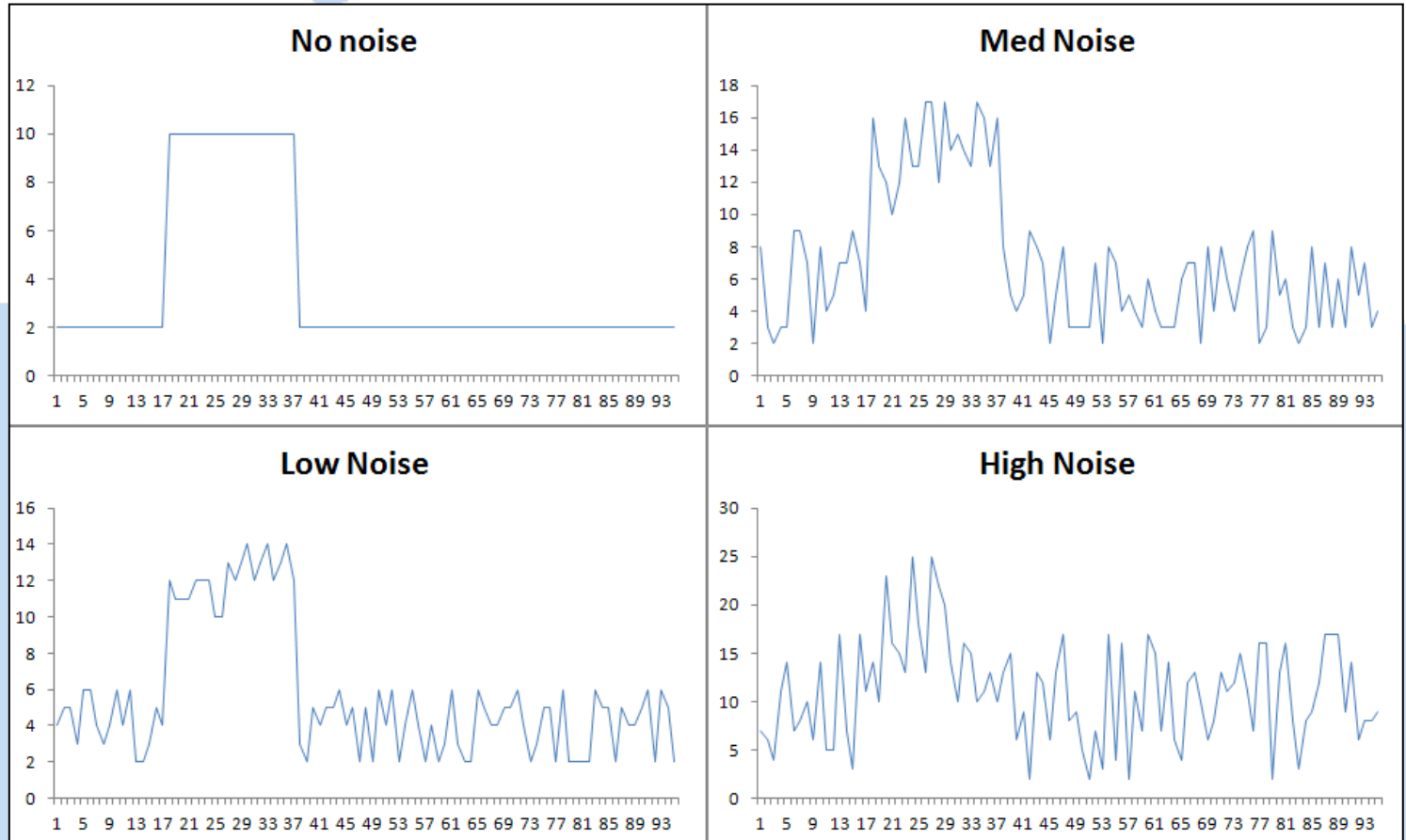
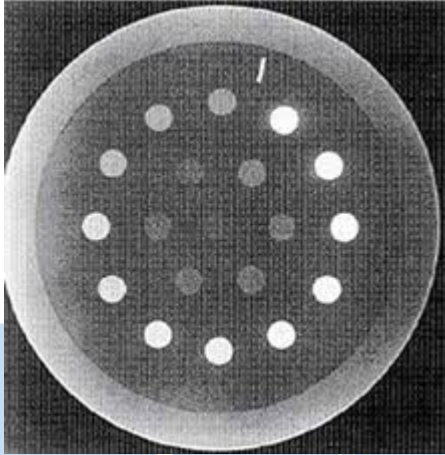


Image Quality – Noise



TG18-AFC Pattern
Version 8.0, 12/01
Copyright © 2001 by AAPM

APPROXIMATE

PERCENTAGE

100%
90%
80%
70%
60%
50%
40%
30%
20%
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APPROXIMATE

PERCENTAGE

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Image Quality – Noise

- What causes noise?
 - Quantum Noise
 - Random statistical nature of interaction of photons
 - Overcome by increasing number of photons (dose)
 - Electronic
 - Structural



Image Quality – Resolution

- Ability of the system to pick up detail

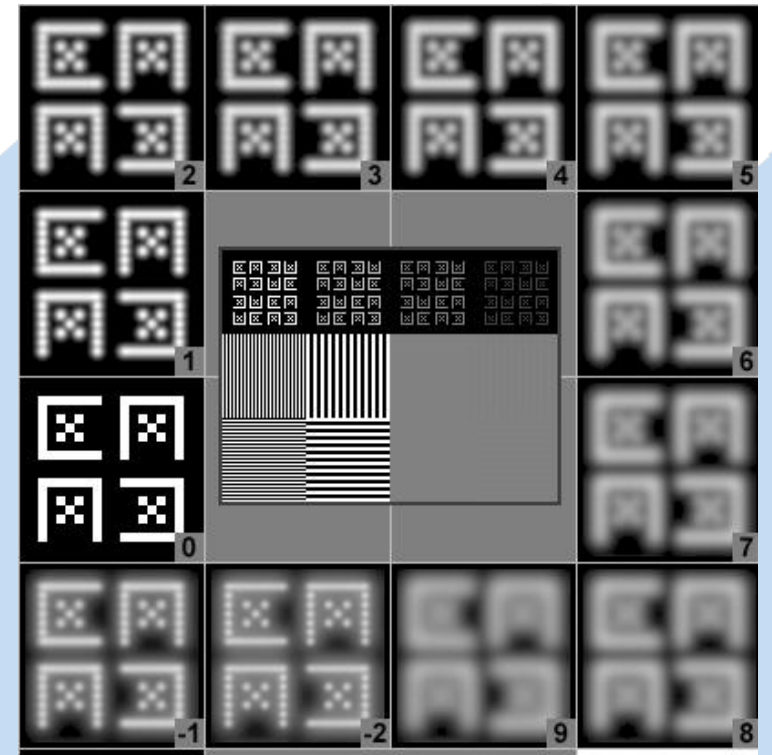
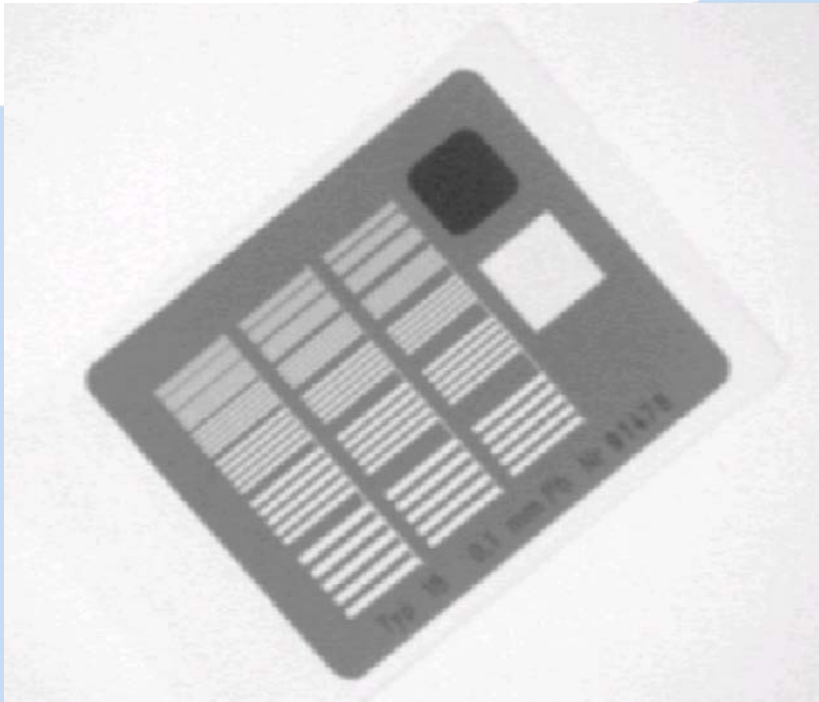


Image Quality – Resolution

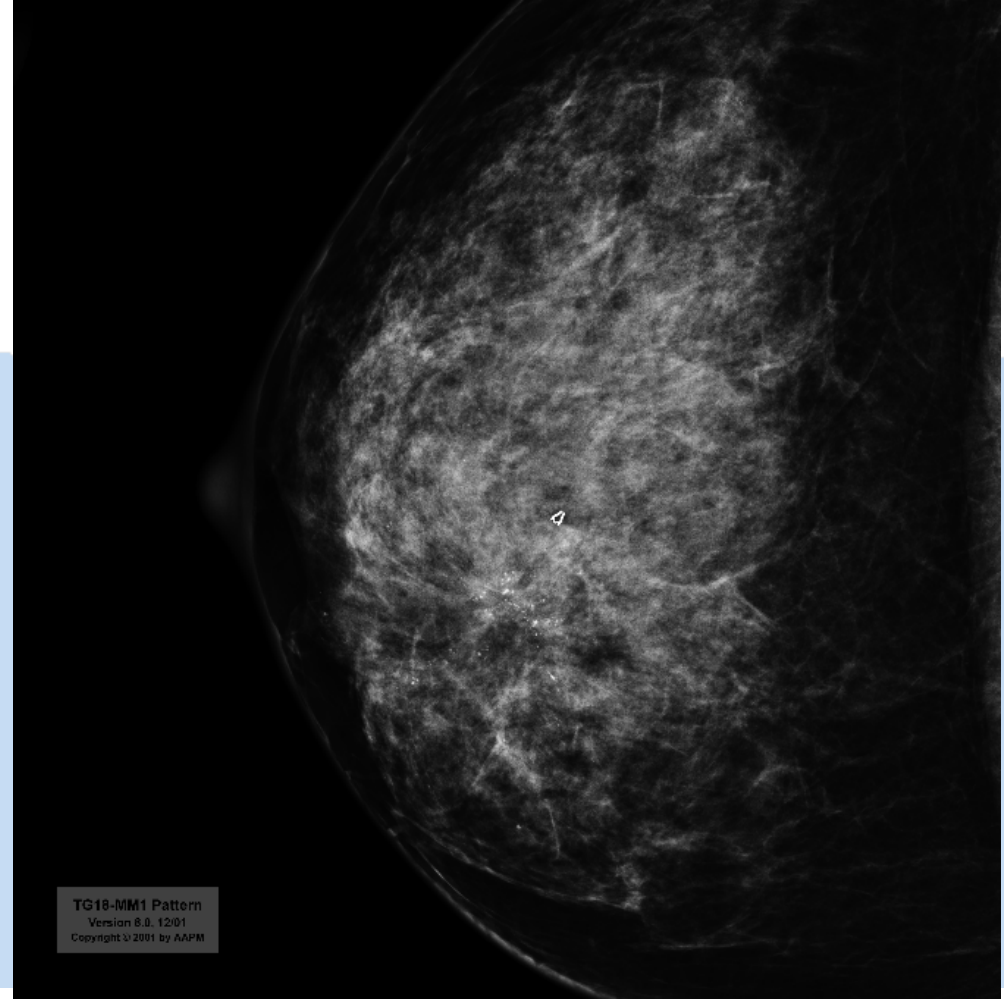


Image Quality – Uniformity

- How does the image vary around the monitor (spatial)
- How does the image vary with time (temporal)
- How does it vary with viewing angle



Image Quality – Artefacts

- Distortion
- Glare/Flaring
- Interference (Moiré)
- Ghosting
- Stitching
- Blurring



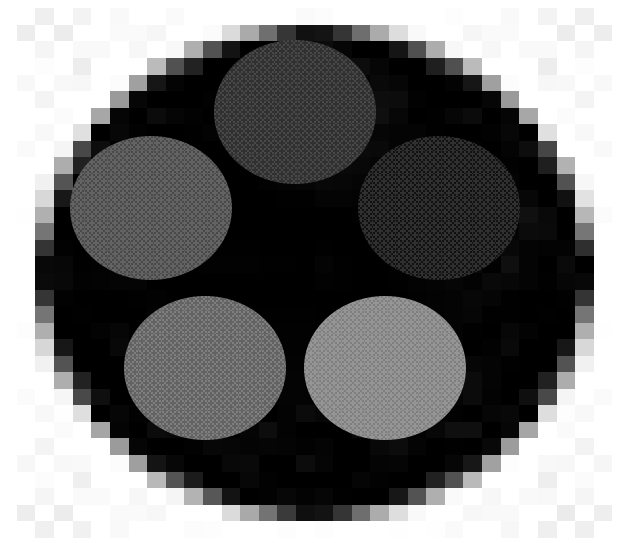
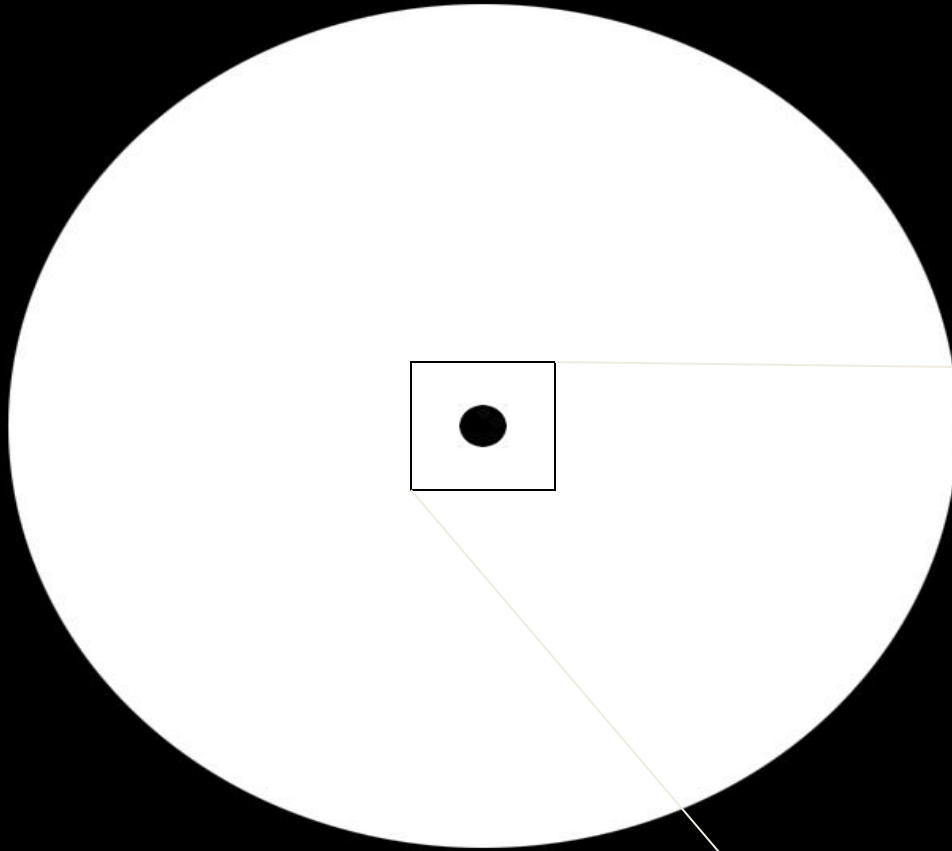


Image Quality – Artefacts

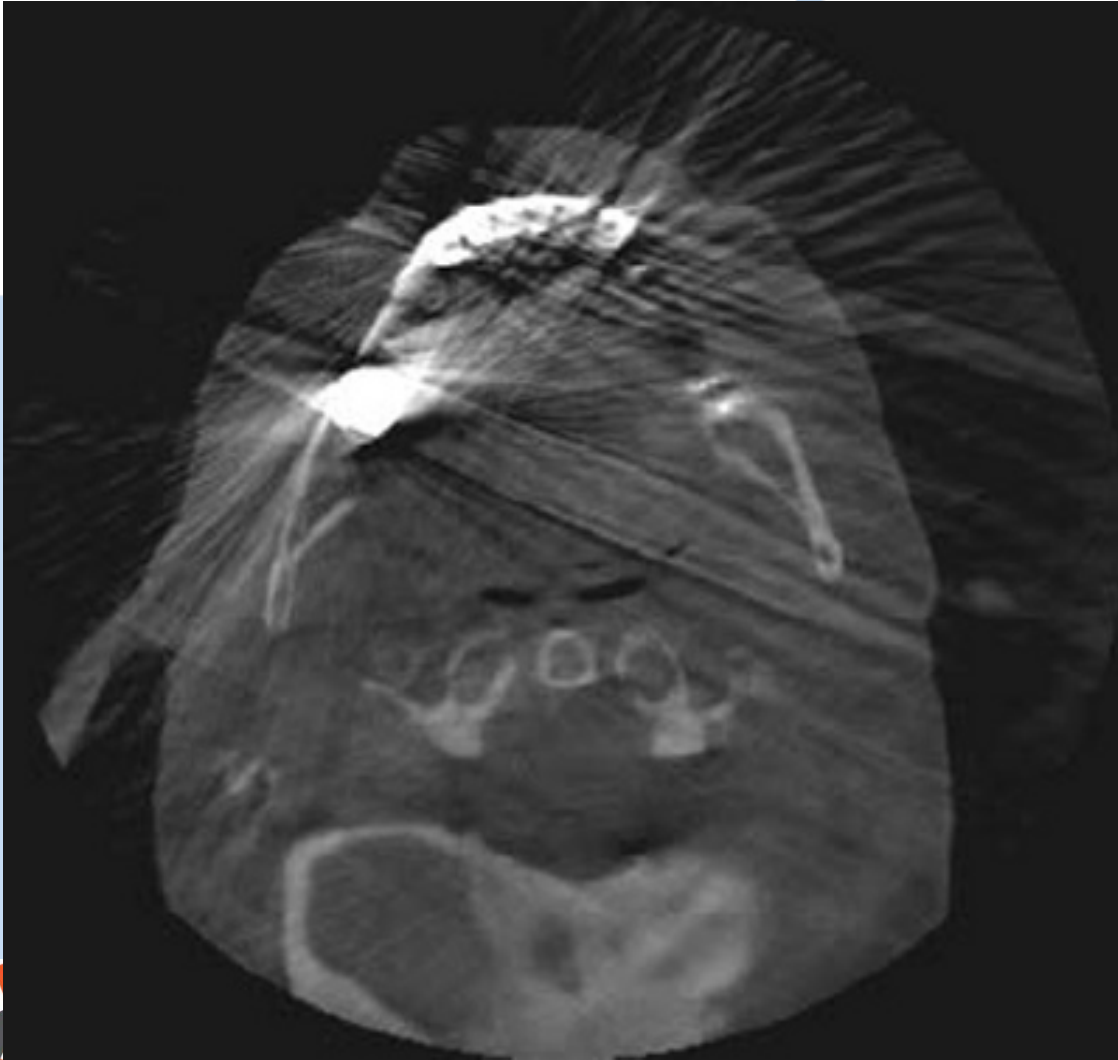


Image Quality – Artefacts

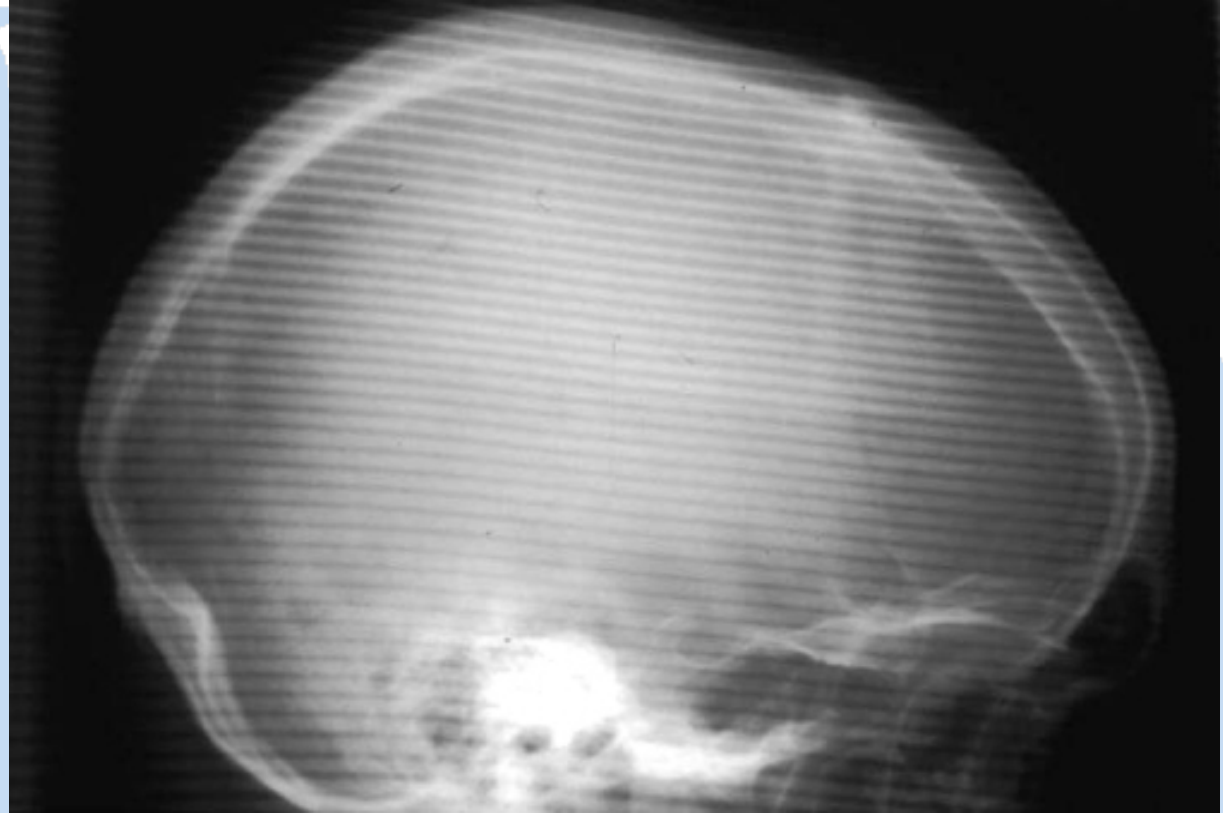
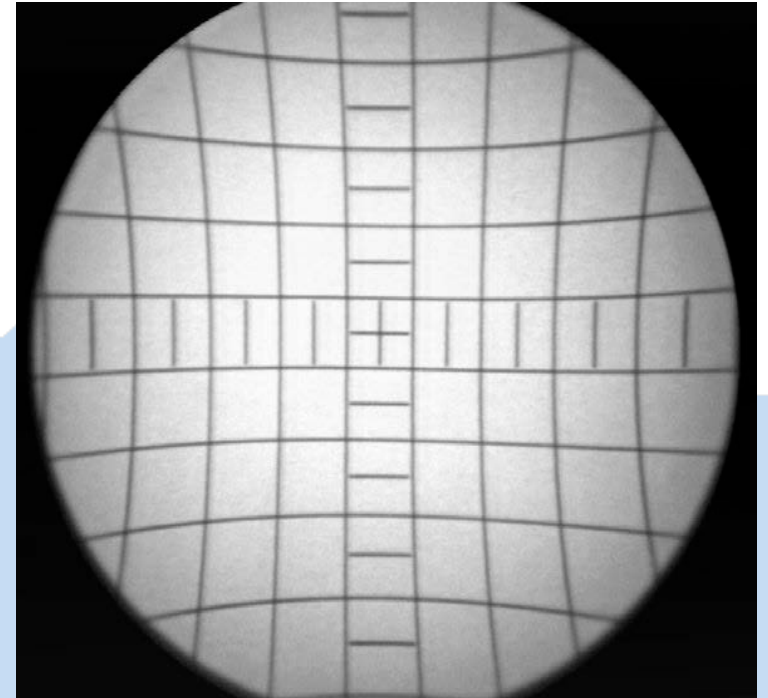
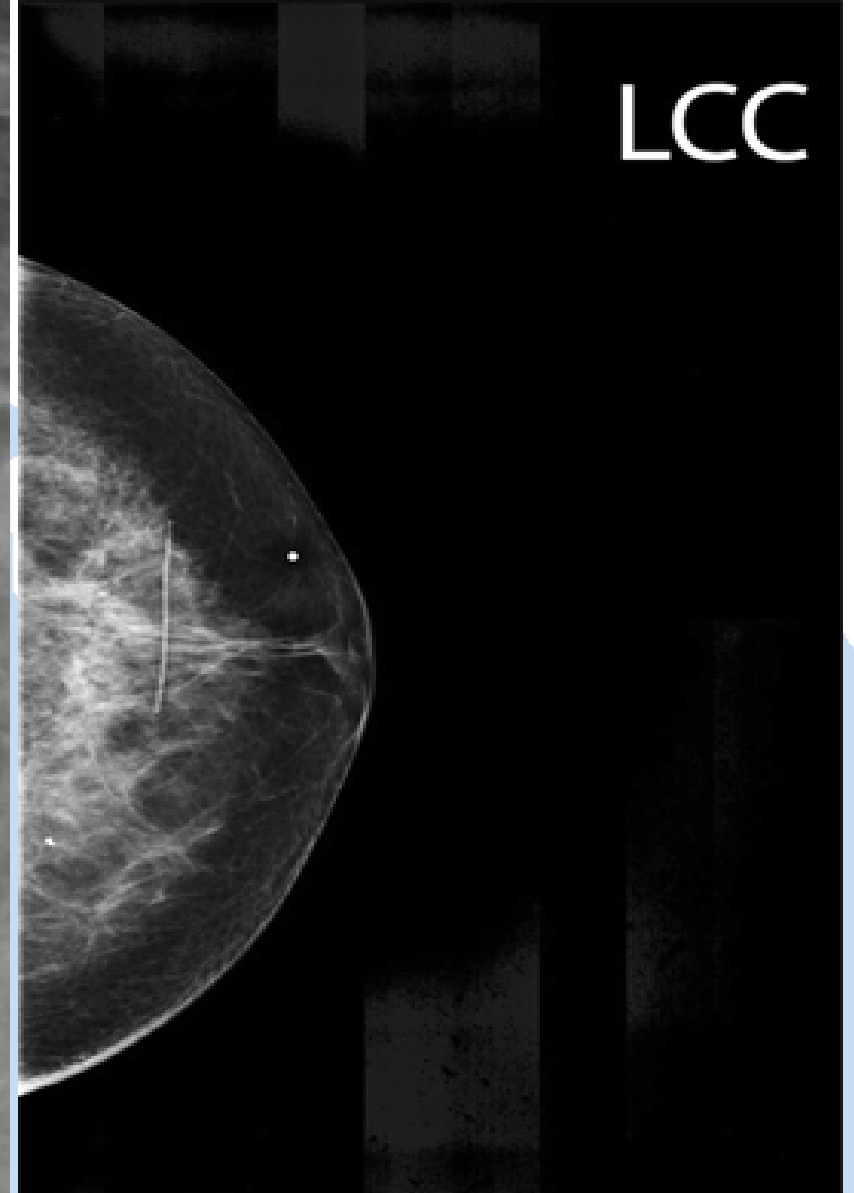
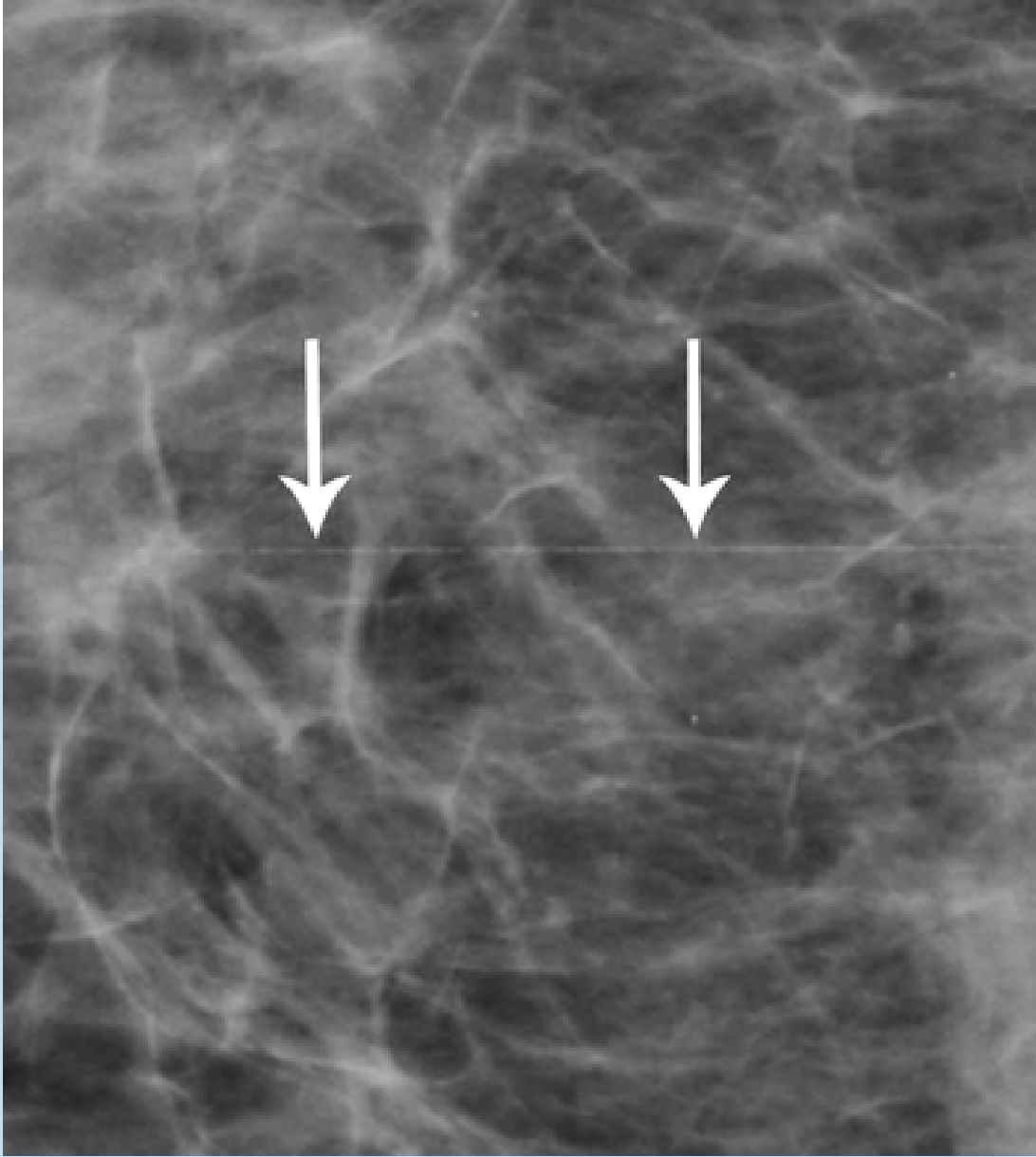


Image Quality – Artefacts





- Digital Mammographic Artifacts on Full-Field Systems: What Are They and How Do I Fix Them?:
- <http://radiographics.rsna.org/content/28/7/1999.full>



10 *Recommended Standards for the Routine Performance Testing*

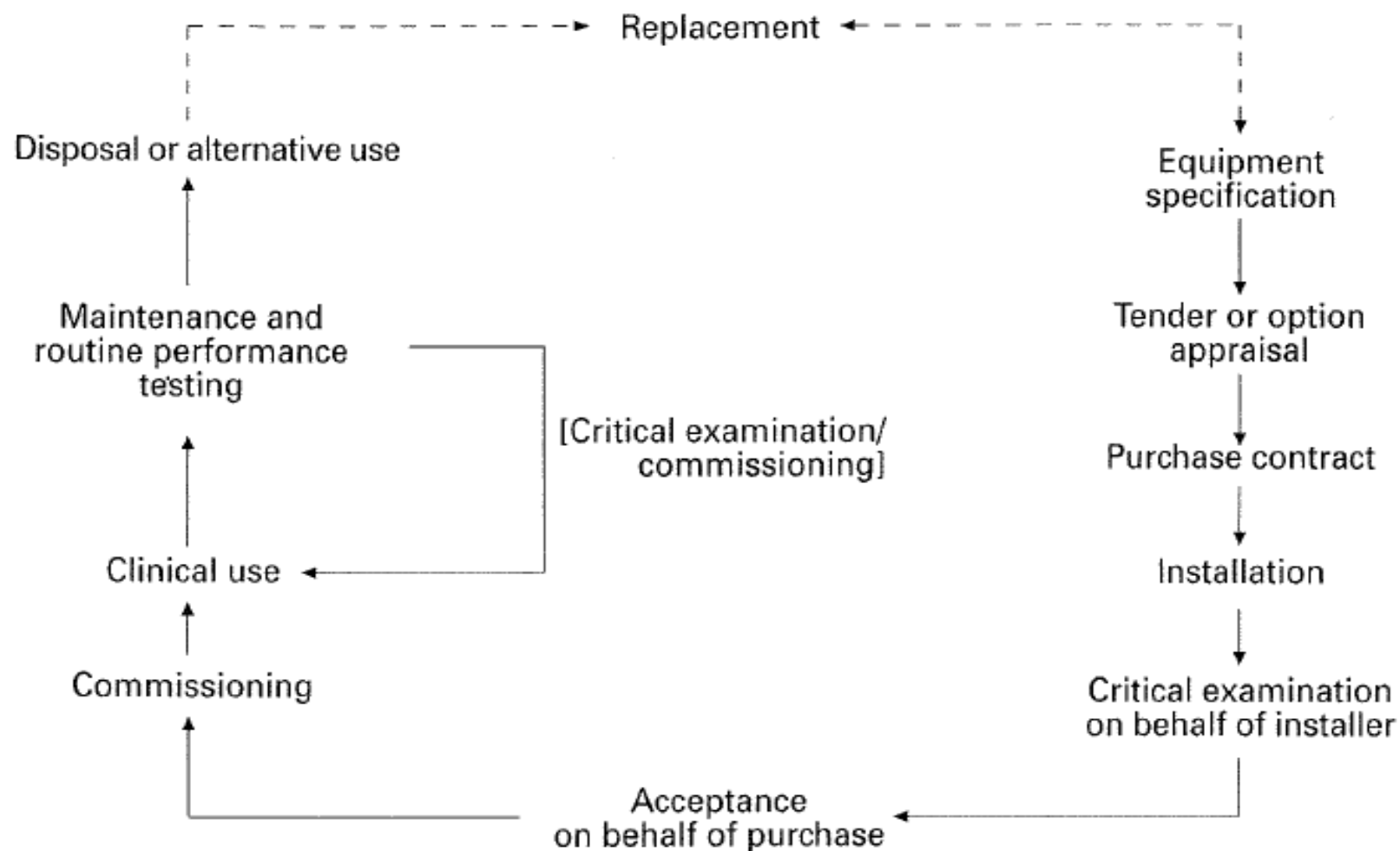


Figure 2.1 Life cycle of x-ray imaging systems



What is a QA programme

- A quality assurance programme in diagnostic radiology as defined by the WHO is an organized effort by the staff operating a facility to ensure that the diagnostic images produced are of sufficiently high quality so that they consistently provide adequate diagnostic information at the lowest possible cost and with the least possible exposure of the patient to radiation

(IAEA Training Lecture)



Benefits of a QA programme

- **QA can be of great value in:**

Improving diagnostic content

Reducing radiation exposure

Reducing medical costs

Improving departmental management

(IAEA)



Background

- IRR 99, Reg 32 Equipment used for Medical Exposure
 - WHO Radiation employer
 - WHAT Install & maintain equipment so as to restrict the exposure from ionising radiation during medical exposure
 - HOW Provision of a suitable QA programme
 - WHY Patient exposures ALARP



National Standards - IPEM91

Recommended Standards for the Routine Performance Testing of Diagnostic X-ray Imaging Systems

An update of IPEM Report No.77



IPEM 91 – Info on QA Tests

Chapters on testing of:

- X-Ray tubes and generators
- Film/screen radiography, processors and automatic exposure control devices
- Computed radiography (CR)
- Direct digital radiography (DR)
- Image display and hardcopy devices
- Mammography
- Dental radiography
- Fluoroscopy
- Fluorography
- Computed tomography (CT)
- Patient dose measurements



Level of Expertise

Level A Tests

- Undertaken by radiographic staff of radiology department
- Radiographic specific
- Frequent
- Quick
- Simple - Pass / Fail
- No sophisticated equipment
- No detailed analysis



Level of Expertise

Level B Tests

- Undertaken by medical physics staff / service engineers / specially trained radiographers
- Less frequent
- More analytical
- Greater equipment resource and expertise



Frequency

- Varies from daily to 3-yearly.
- Often stated as a range e.g. 3-6 monthly
- Frequency selected will depend on:
 - Age of equipment
 - Clinical workload



What are you checking for?

- Compliance with minimum absolute values e.g. x-ray/light beam alignment.
- Measurements not differing significantly from 'Baseline values'



Tolerances – Remedial Level

- Sometimes called an investigation level
- Level of performance at which investigative action needs to be undertaken
- Won't usually be image quality or patient dose implications at this stage.



Tolerances- Suspension level

- A level of performance at which it is recommended that the imaging equipment be removed from clinical use.



Image Quality – Summary

- Images should be 'adequate' enough to answer clinical question
- Image quality can be influenced at many points along the imaging chain
- There are a number of parameters for image quality
- A good QA programme should be in place to assess image quality

