
HAMAD DARWISH
KBR PART ONE PHYSICS SYLLABUS
PROJECTION IMAGING

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TOPICS
X-RAY TUBE
X-RAY BEAM
EXPOSURE FACTORS
DIGITAL RADIOGRAPHY
IMAGE QUALITY
IMAGE EVALUATION
KBR PART ONE PHYSICS SYLLABUS
PROJECTION IMAGING

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TOPICS
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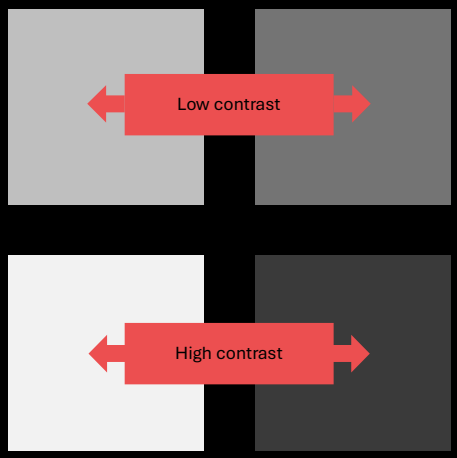
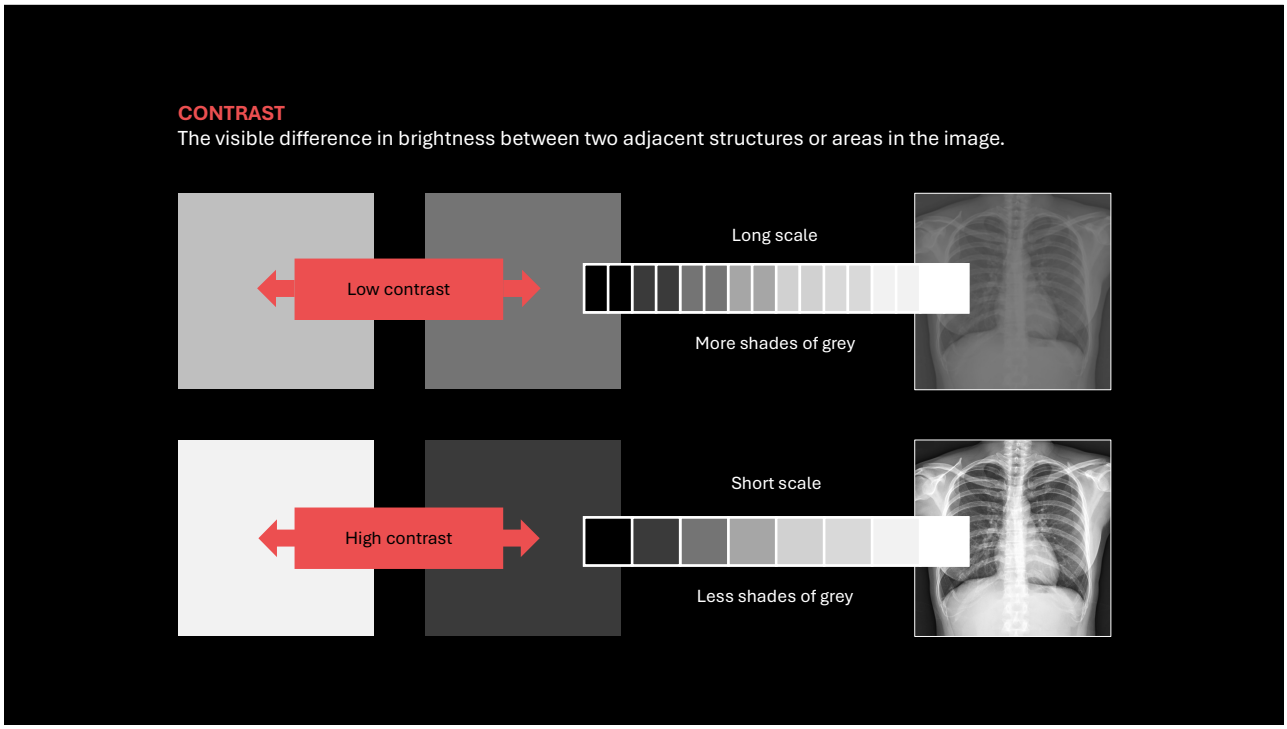
CONTRAST
The visible difference in brightness between two adjacent structures or areas in the image.



211


CONTRAST
The visible difference in brightness between two adjacent structures or areas in the image.
Low contrast
Long scale
More shades of grey
High contrast
Short scale
Less shades of grey

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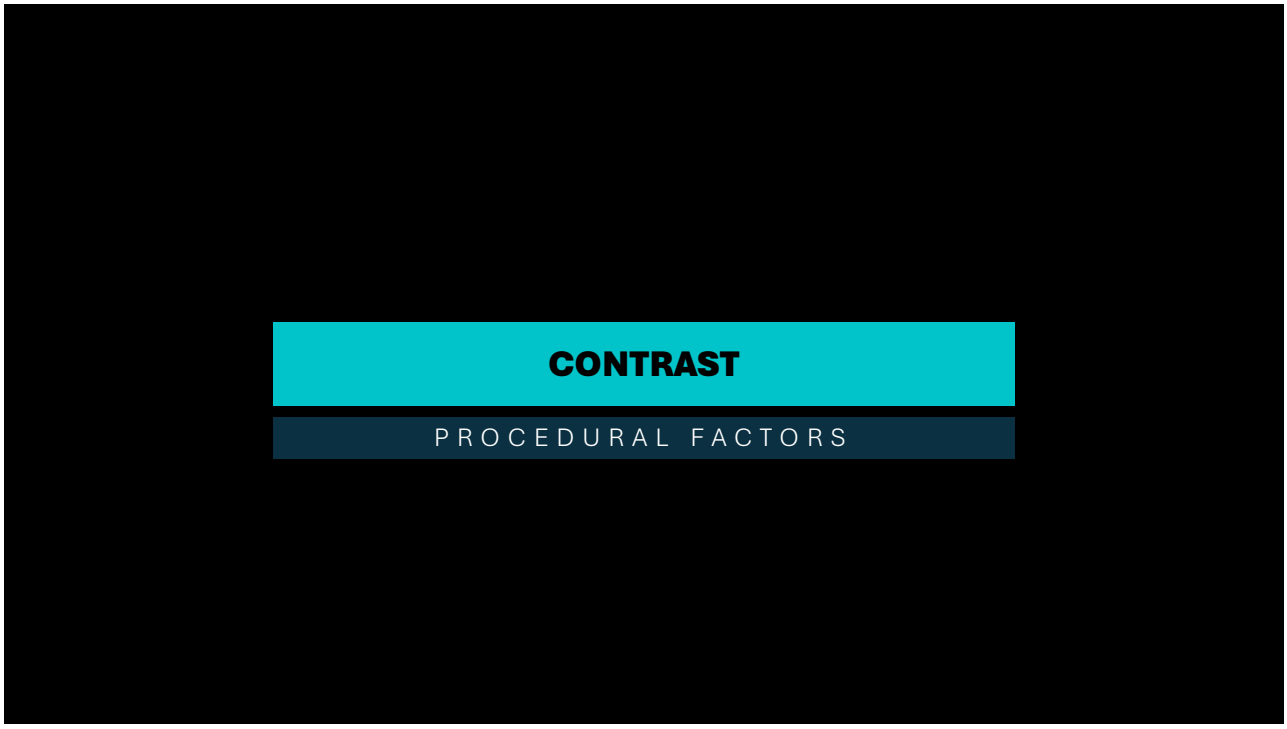
CONTRAST
PROCEDURAL FACTORS

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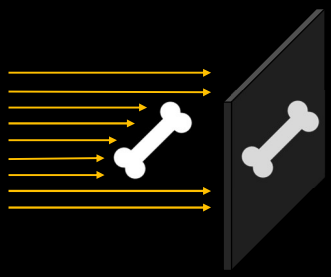
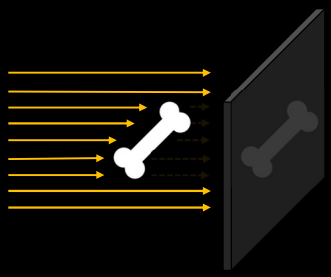
kVp

Image Contrast

Increasing kVp increases beam penetration. The beam will therefore penetrate both low-density and high-density subjects easily. This will erase the difference between the two densities



At **low kVp**, X-Ray photons will be **absorbed** by high-density subjects; creating their shadow on the image (**high image contrast**)



At **high kVp**, X-Ray photons will **penetrate** high-density subjects; Reducing or completely erasing their shadow on the image (**low image contrast**)

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kVp

Image Contrast

Increasing kVp increases scatter generation which reduces image contrast by "**fogging**" the entire image with a uniform layer of density than simply erases the image contrast.

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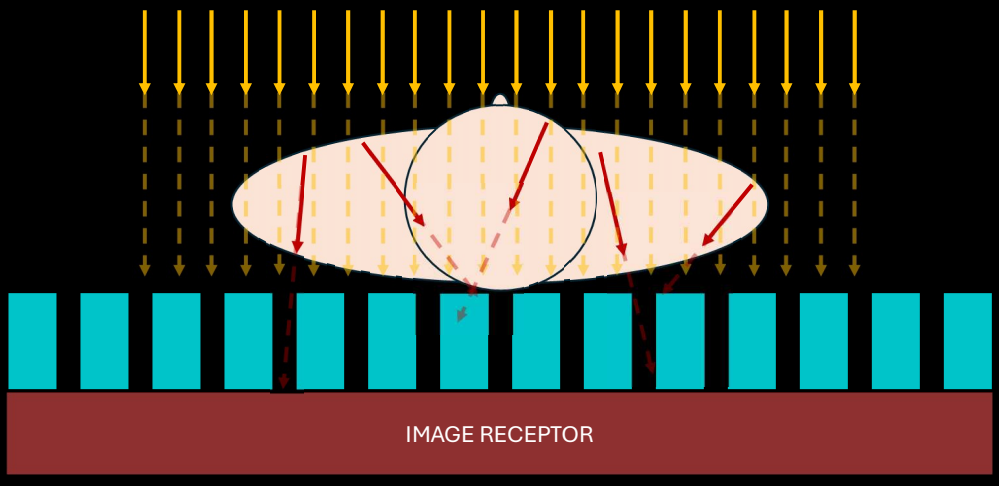
The **Grid** only allows photons from a certain trajectory to pass through to the image receptor. The **grid absorbs most scattered photons** (photons from odd trajectories) and **some of the useful photons** unfortunately.



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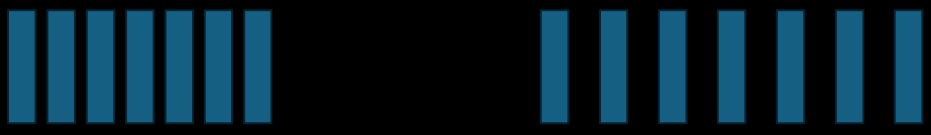
The **Grid Ratio** is the relationship between **the height of the lead strips** and **the distance between them**. The higher the grid ratio, the more efficient is the grid at absorbing scatter radiation but a **higher exposure is required to compensate** for the significant decrease in photons reaching the image receptor.



HIGH **Grid Ratio**

16 : 1

LOW **Grid Ratio**

5 : 1

INCREASING GRID RATIO

↑ Image Contrast

↓ Image density (blackness)

↑ Patient Dose (indirectly)

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CONTRAST

SUBJECT CONTRAST

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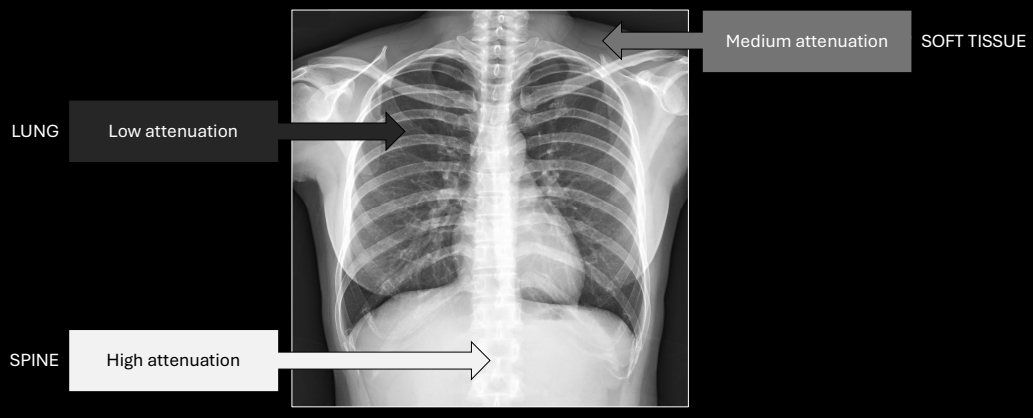
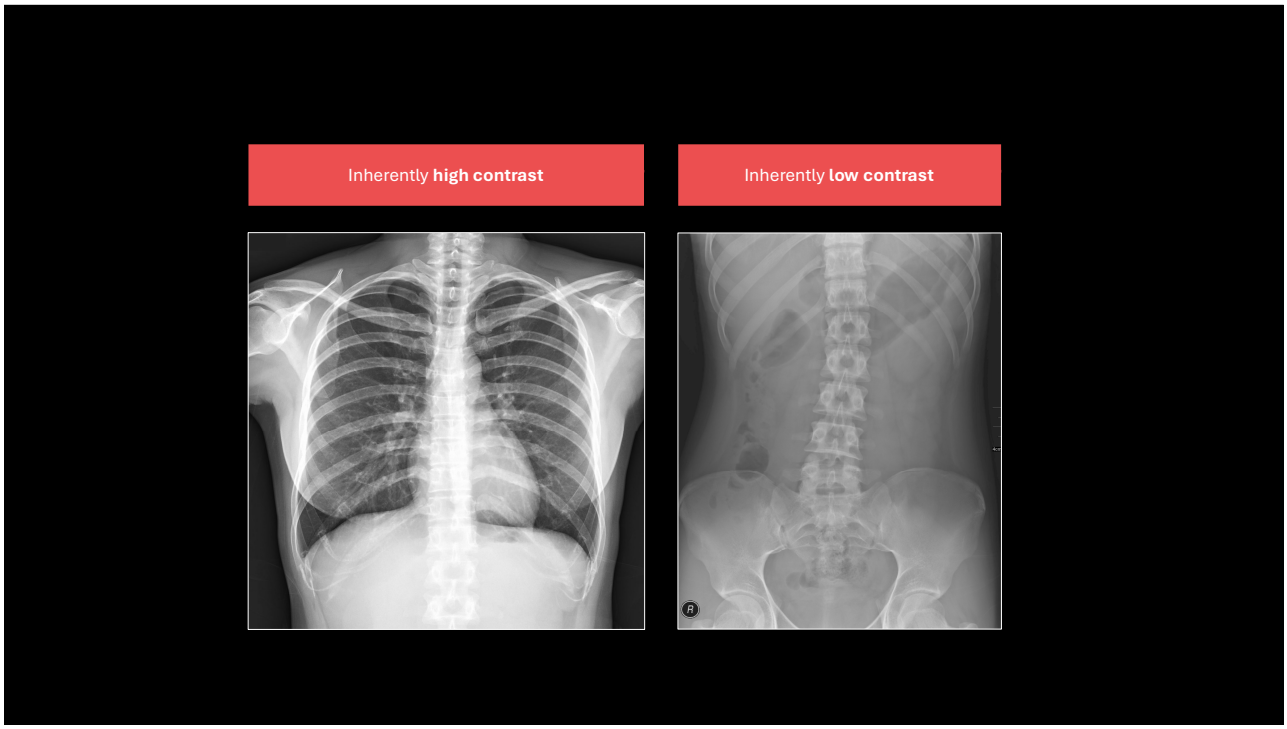
SUBJECT CONTRAST

The amount of signal difference in the remnant beam as a result of the **different levels of absorption of tissue types** being imaged.



219


Inherently **high contrast**
Inherently **low contrast**

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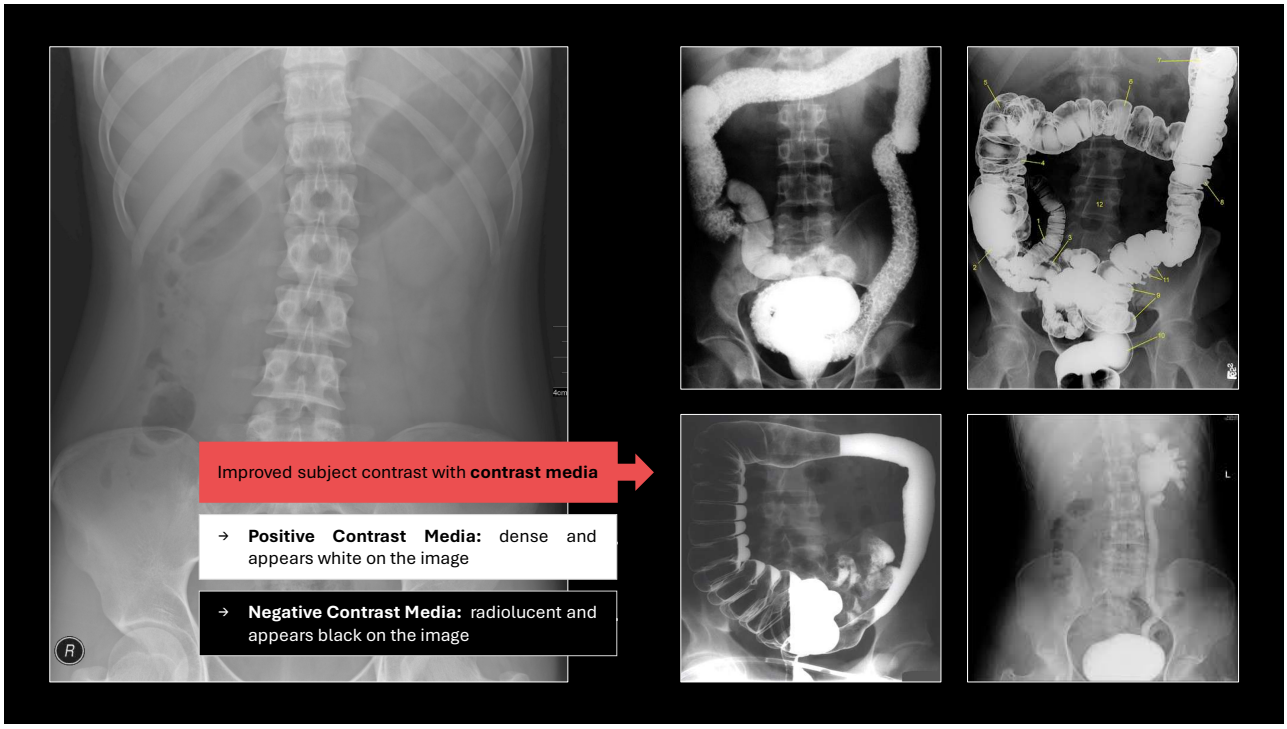
Improved subject contrast with **contrast media**
→ **Positive Contrast Media:** dense and appears white on the image
→ **Negative Contrast Media:** radiolucent and appears black on the image

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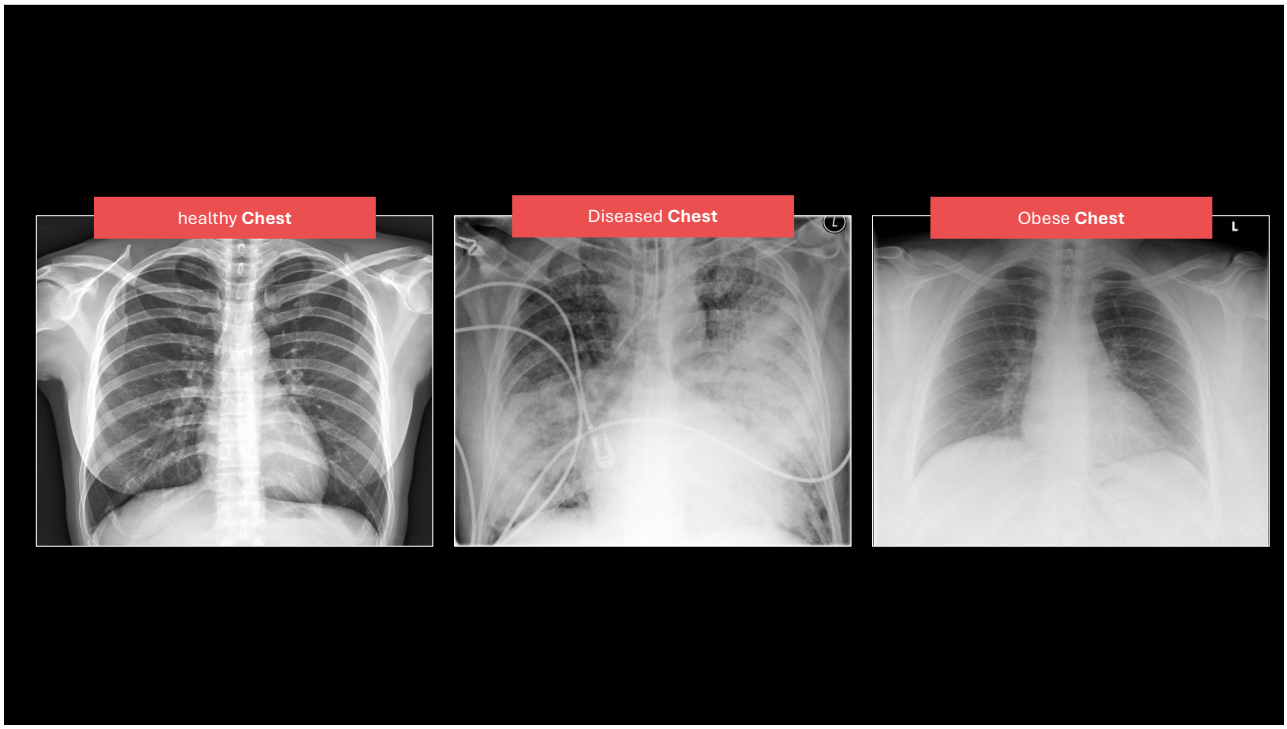

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CONTRAST

DIGITAL FACTORS

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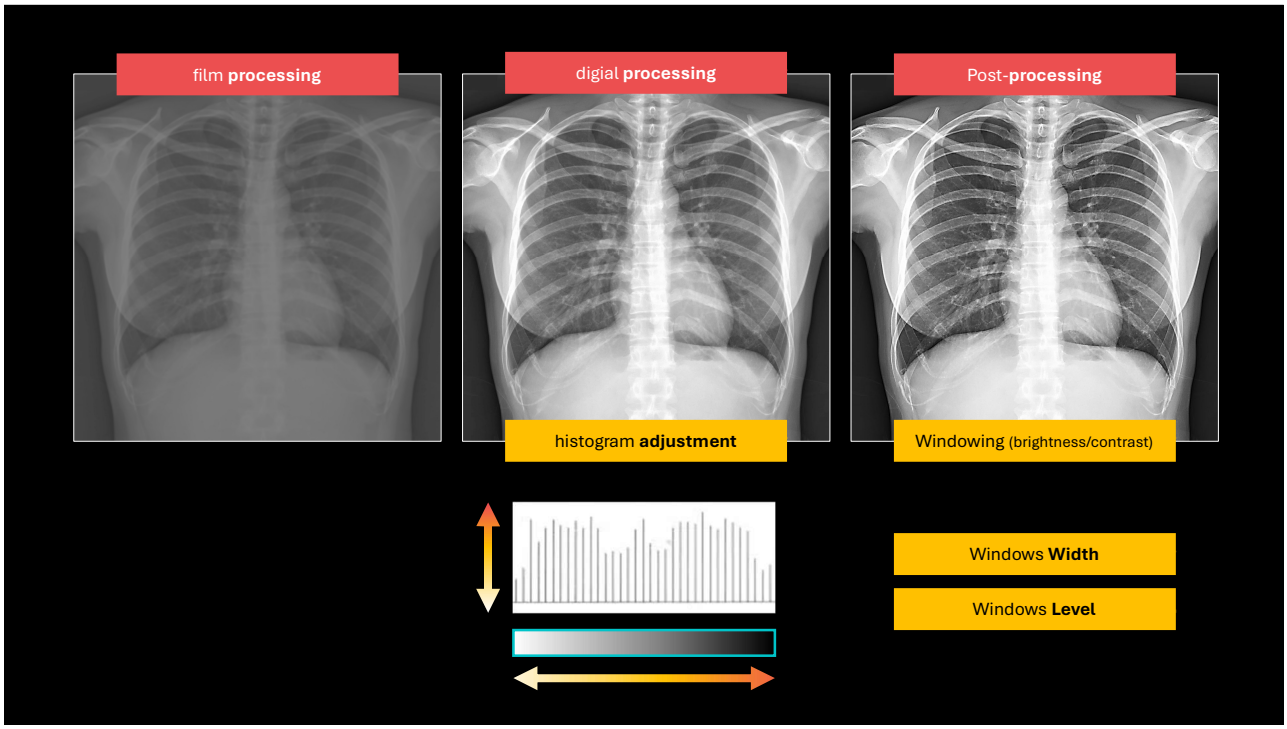
film **processing**
digial **processing**
Post-**processing**
histogram **adjustment**
Windowing (brightness/contrast)
Windows **Width**
Windows **Level**

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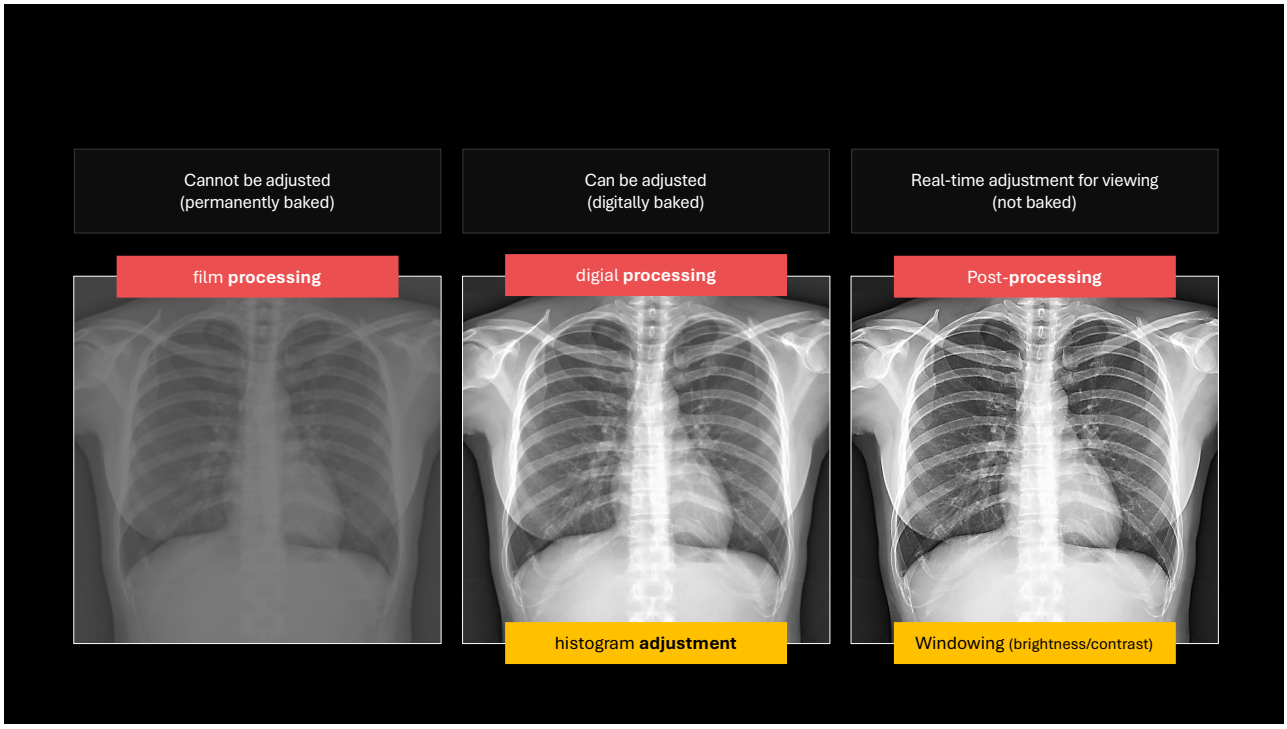
Cannot be adjusted
(permanently baked)
Can be adjusted
(digitally baked)
Real-time adjustment for viewing
(not baked)
film **processing**
digial **processing**
Post-**processing**
histogram **adjustment**
Windowing (brightness/contrast)

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SPATIAL RESOLUTION

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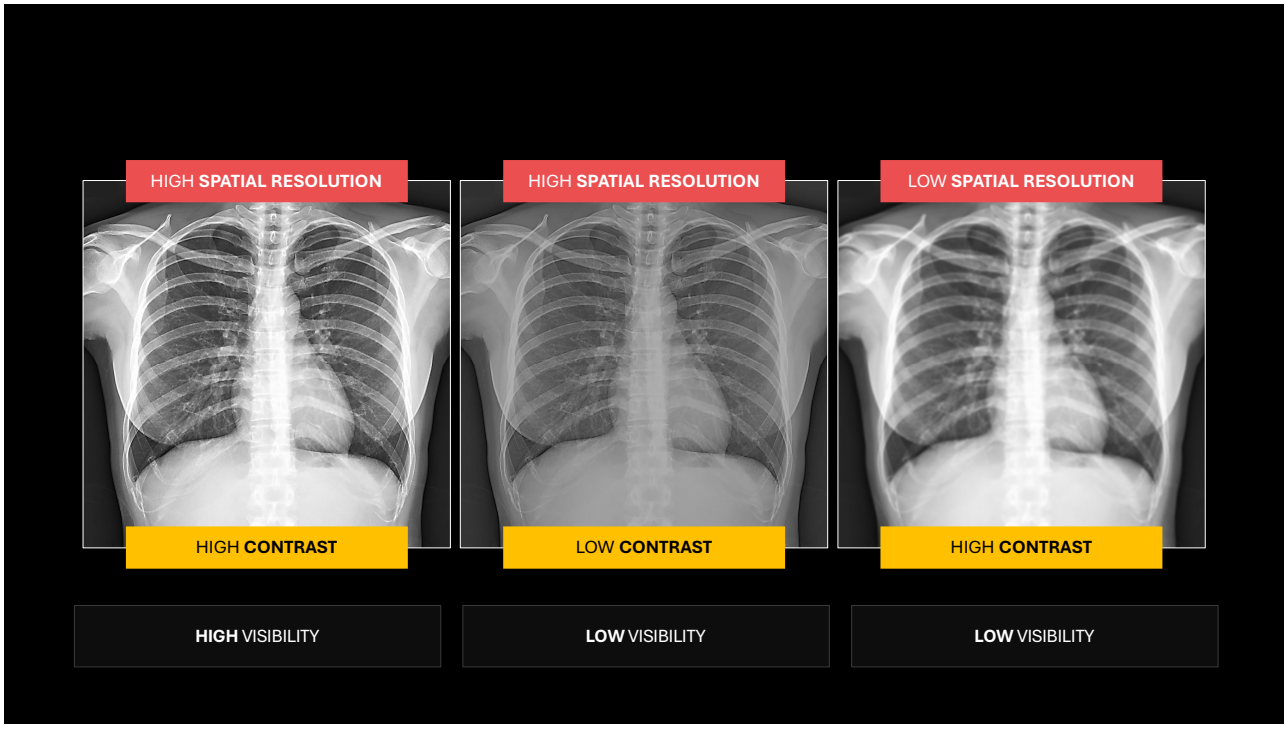

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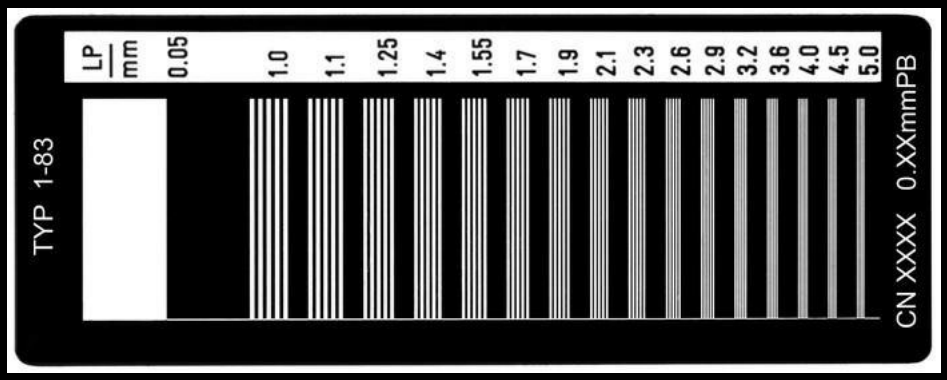
SPATIAL RESOLUTION

In radiography, spatial resolution is the ability of an imaging system to distinguish between two small, closely positioned objects as separate entities. It defines the degree of geometric sharpness or accuracy of structural lines within a radiograph



Line Pair per Millimeter (LP/mm) resolution test pattern used to measure the spatial resolution X-Ray imaging systems

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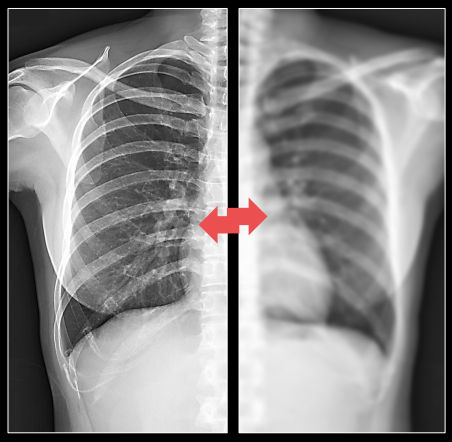
SPATIAL RESOLUTION

Is affected by many factors …

- **Patient Factors:**
  - Movement
- **Beam geometry:**
  - SID
  - OID
  - Focal Spot size
- **Image receptor factors:**
  - DEL size
  - Pitch
  - Fill Factor
- **Digital image factors:**
  - Pixel Size
  - Matrix
- **Digital display factors:**
  - Pixel Size
  - Matrix



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SPATIAL RESOLUTION

PATIENT FACTORS

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Motion is most of the time (not always) not desired during imaging. **It blurs objects and negatively affects image quality**.

Motion can be eliminated by simple instructions (i.e, do not move, or hold your breath).

Motion can also be eliminated by improving temporal resolution – shorter exposure times.

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SPATIAL RESOLUTION

BEAM GEOMETRY FACTORS

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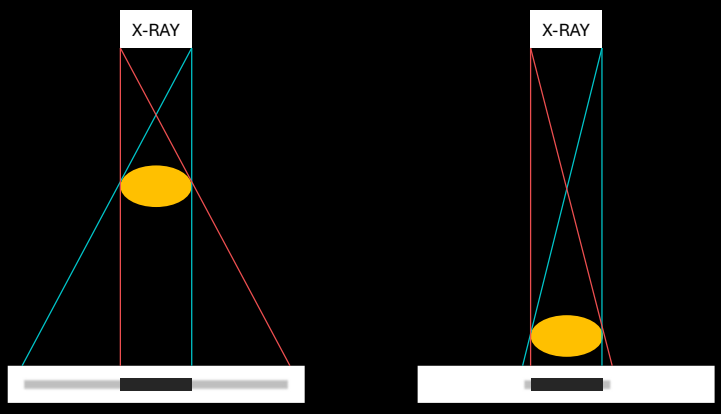
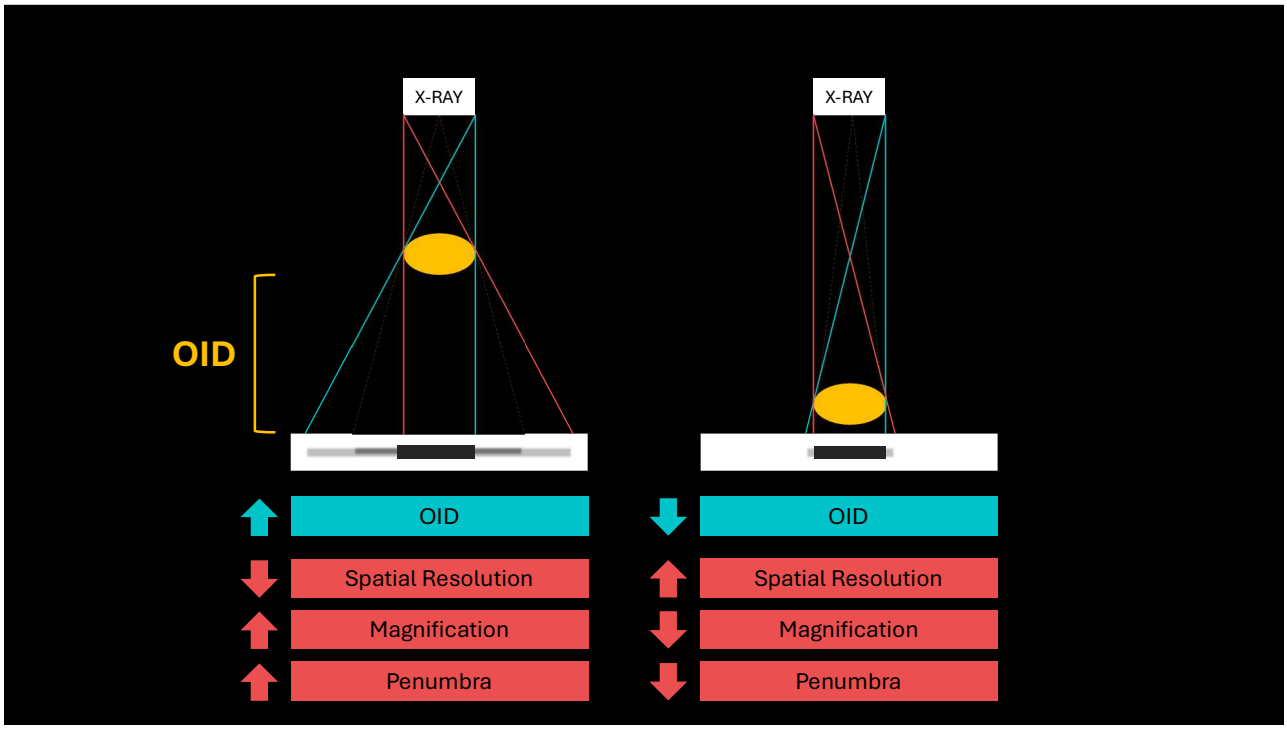
OBJECT-IMAGE-DISTANCE (OID)
Distance between the subject (patient or body part) and the image receptor. It **affects magnification** and **penumbra** (area of unsharpness around objects).



233



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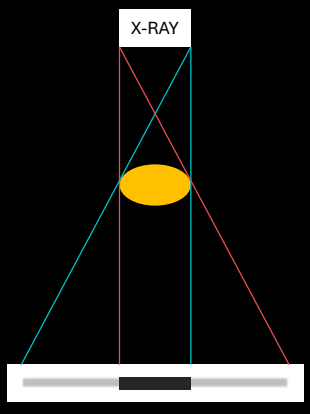
SOURCE-IMAGE-DISTANCE (SID)
Distance between the X-Ray source and the image receptor. It **affects magnification** and **penumbra** (area of unsharpness around objects).



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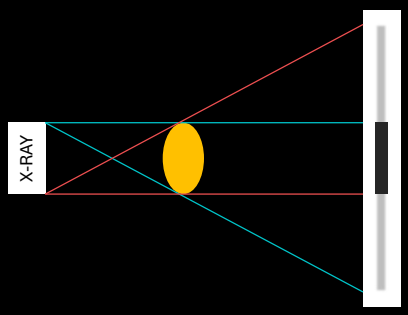
SOURCE-IMAGE-DISTANCE (SID)
Distance between the X-Ray source and the image receptor. It **affects magnification** and **penumbra** (area of unsharpness around objects).



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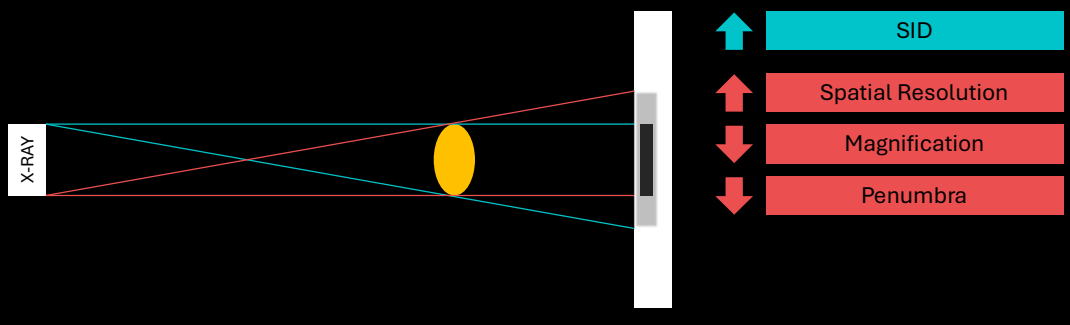
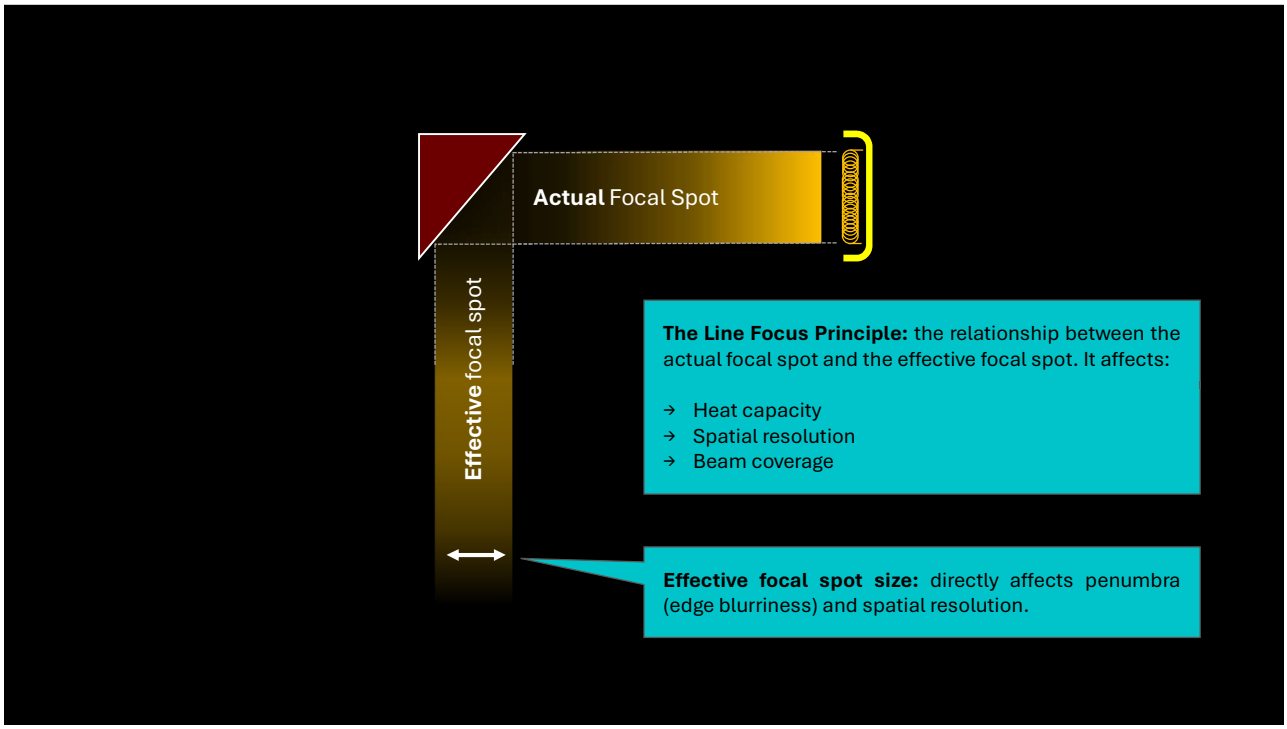
SOURCE-IMAGE-DISTANCE (SID)
Distance between the X-Ray source and the image receptor. It **affects magnification** and **penumbra** (area of unsharpness around objects).



237


Actual Focal Spot
Effective focal spot
The Line Focus Principle: the relationship between the actual focal spot and the effective focal spot. It affects:
→ Heat capacity
→ Spatial resolution
→ Beam coverage
Effective focal spot size: directly affects penumbra (edge blurriness) and spatial resolution.

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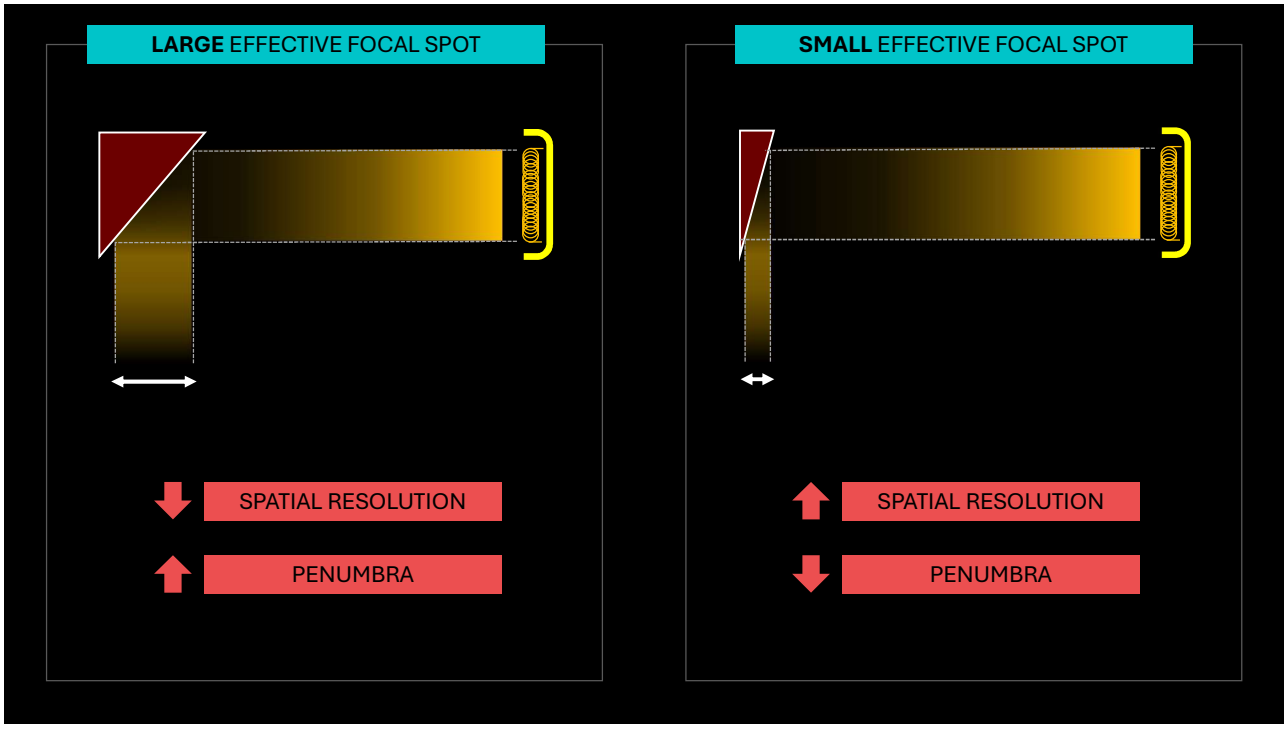
LARGE EFFECTIVE FOCAL SPOT
SPATIAL RESOLUTION
PENUMBRA
SMALL EFFECTIVE FOCAL SPOT
SPATIAL RESOLUTION
PENUMBRA

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SPATIAL RESOLUTION
IMAGE RECEPTOR FACTORS

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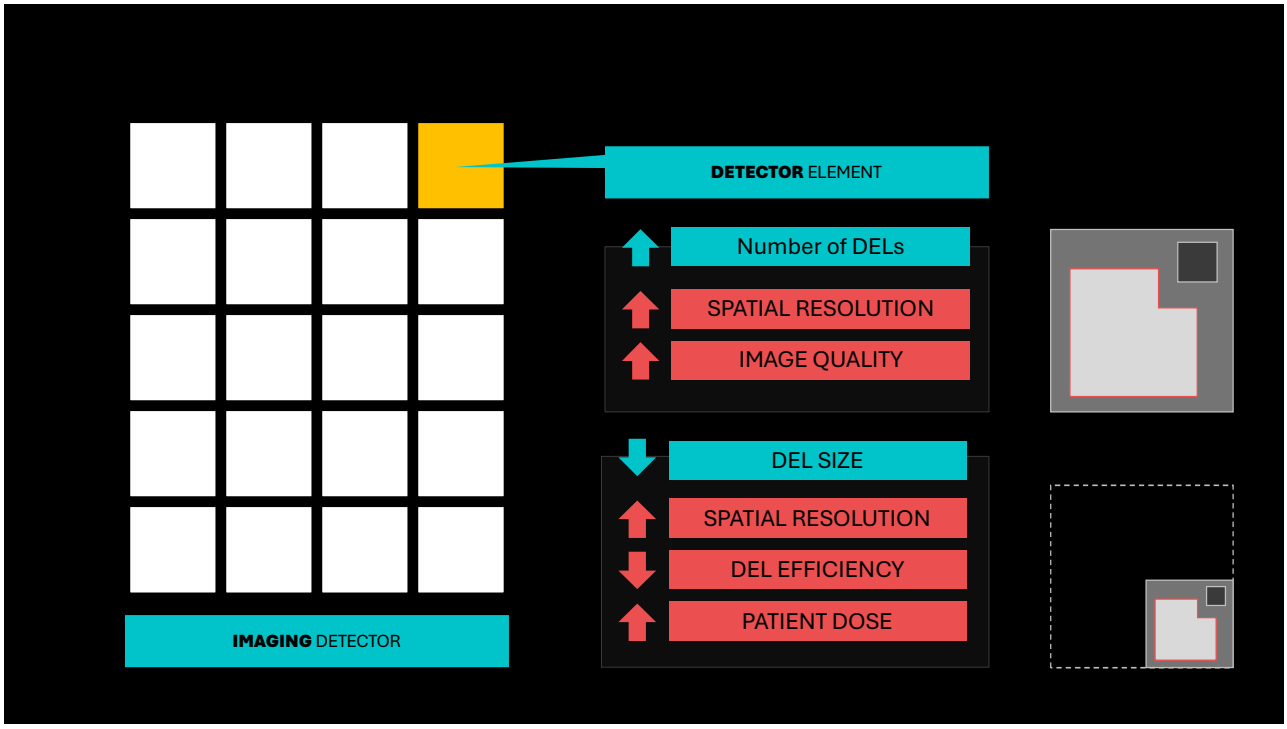
DETECTOR ELEMENT
Number of DELs
SPATIAL RESOLUTION
IMAGE QUALITY
DEL SIZE
SPATIAL RESOLUTION
DEL EFFICIENCY
PATIENT DOSE
IMAGING DETECTOR

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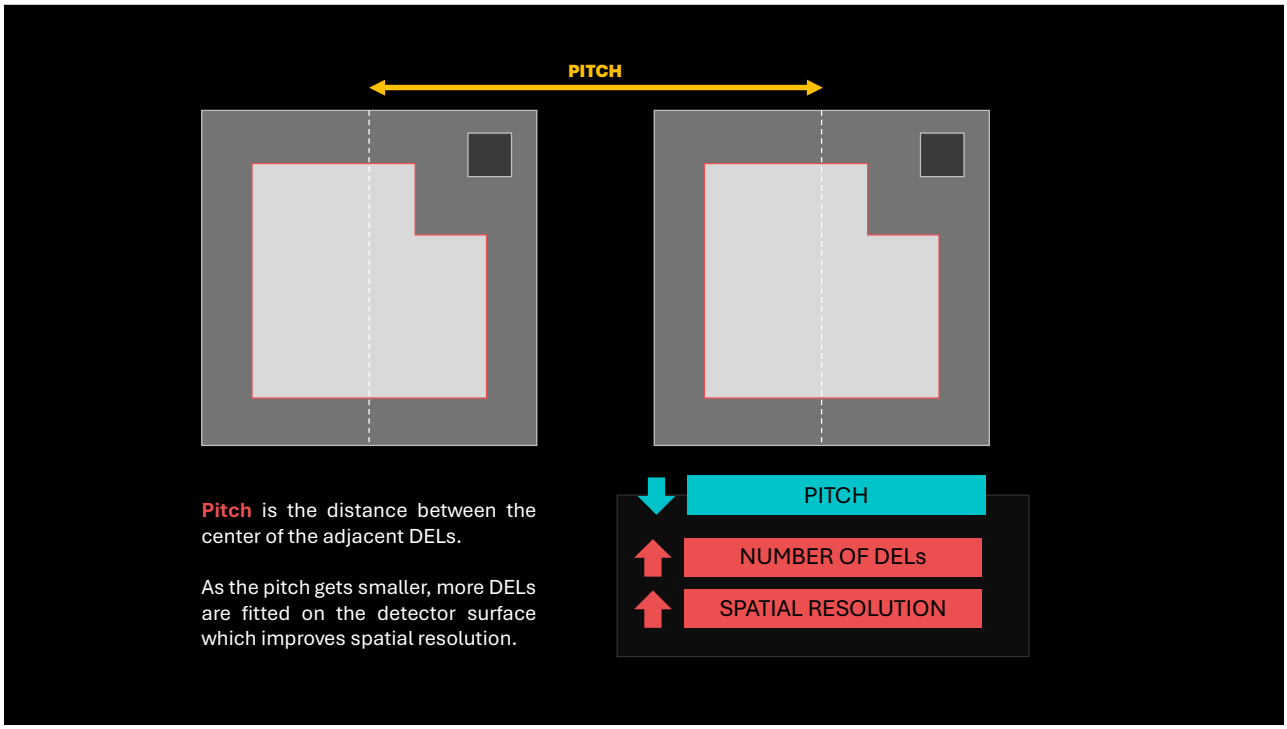
PITCH
Pitch is the distance between the center of the adjacent DELs.
As the pitch gets smaller, more DELs are fitted on the detector surface which improves spatial resolution.
PITCH
NUMBER OF DELs
SPATIAL RESOLUTION

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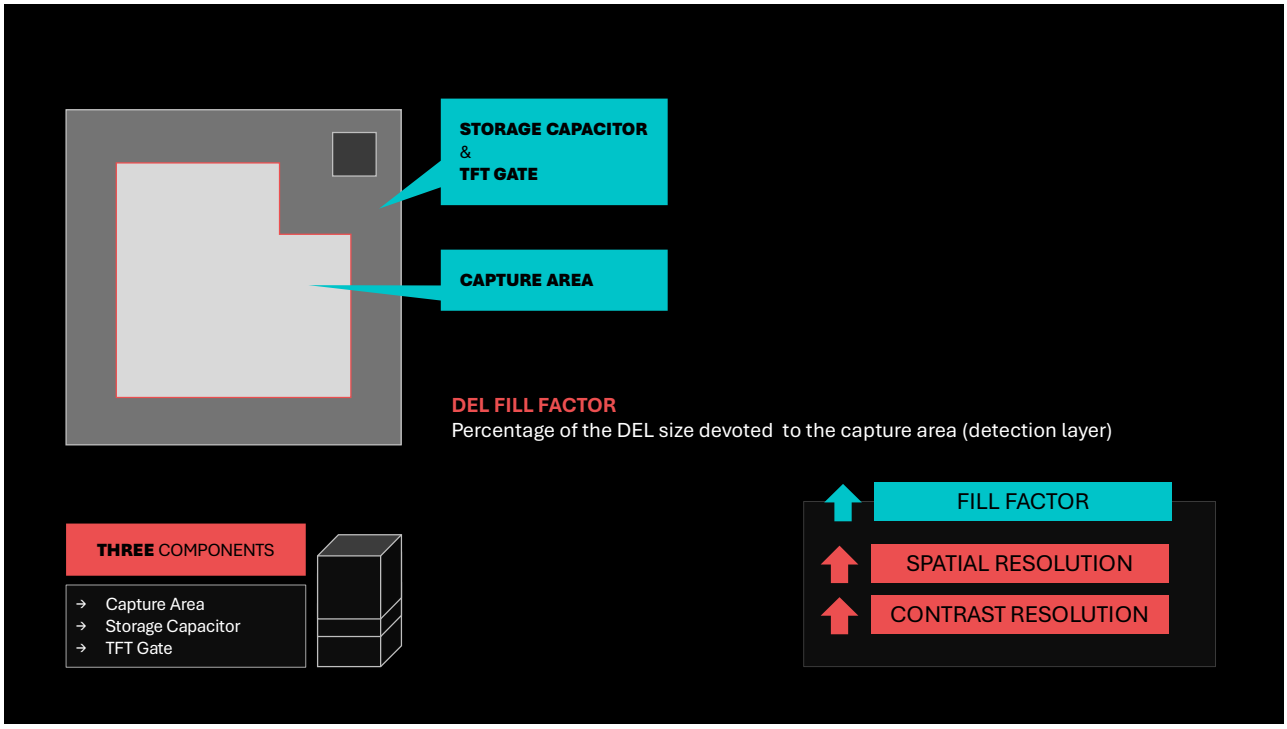
STORAGE CAPACITOR & TFT GATE
CAPTURE AREA
DEL FILL FACTOR
Percentage of the DEL size devoted to the capture area (detection layer)
THREE COMPONENTS
Capture Area
Storage Capacitor
TFT Gate
FILL FACTOR
SPATIAL RESOLUTION
CONTRAST RESOLUTION

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SPATIAL RESOLUTION

DIGITAL IMAGE FACTORS

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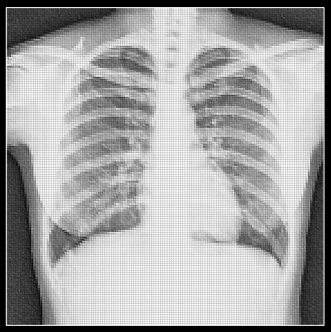
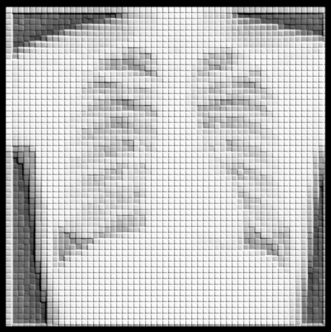
NUMBER OF PIXELS

MATRIX ⟷ PIXEL SIZE

SPATIAL RESOLUTION SPATIAL RESOLUTION





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SPATIAL RESOLUTION

DIGITAL DISPLAY FACTORS

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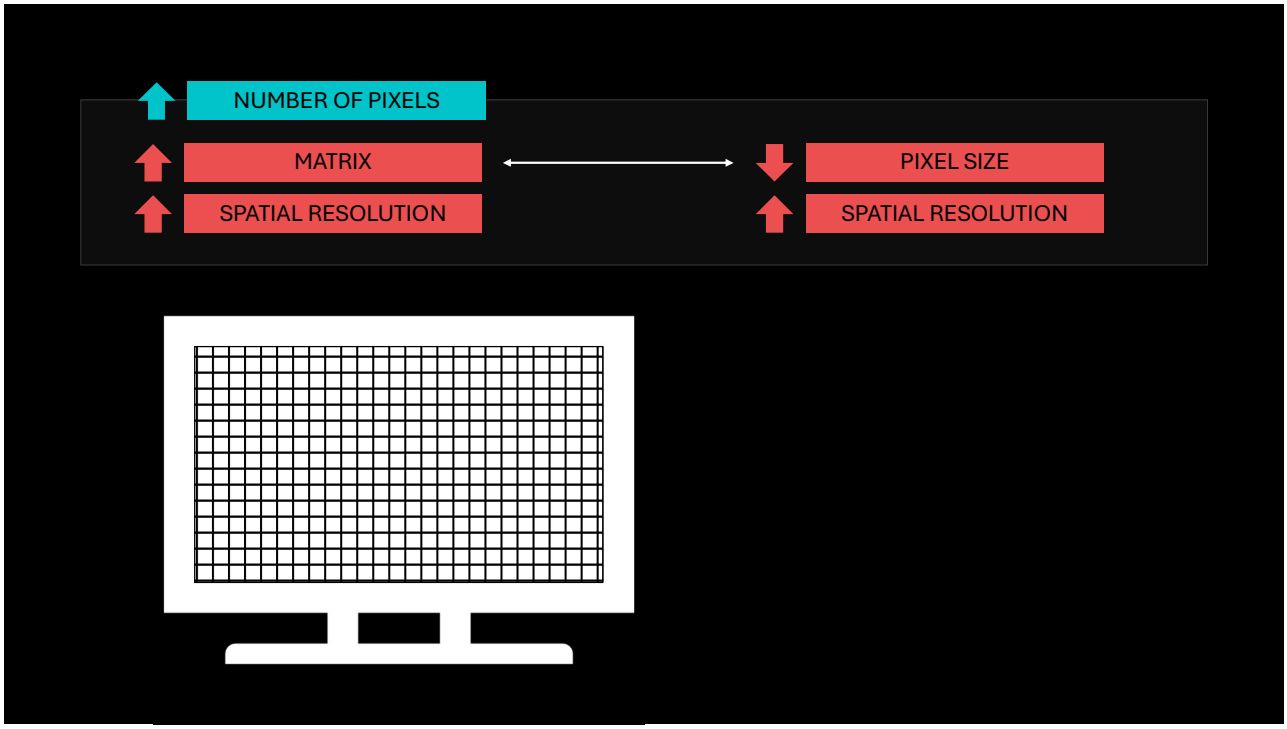
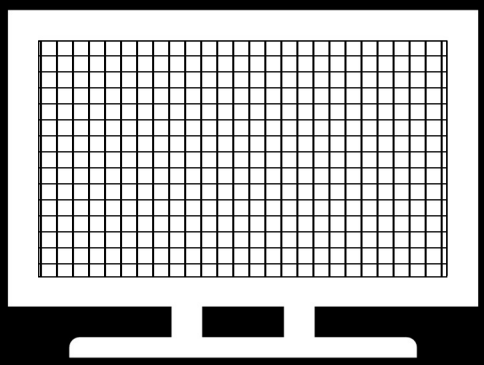


247



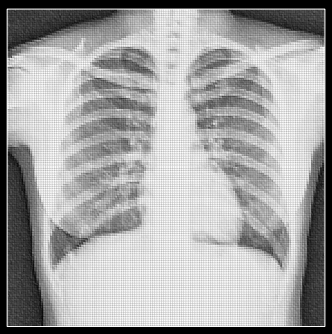


IMAGE MATRIX (RESOLUTION) + **MONITOR MATRIX (RESOLUTION)** + **PIXEL SIZE**
Think of it in these terms...

- **Display Matrix:** A TV can be HD-Ready (720p), FullHD (1080p), or 4K (2160p)
- **Image Matrix:** A movie can be recorded in old vhs (240p), FullHD (1080p), or 4k (2160p)
- **Display Pixel Size:** The pixels are smaller of a 40 inch 4K TV compared to an 80 inch 4K TV.

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IMAGE QUALITY

MAGNIFICATION

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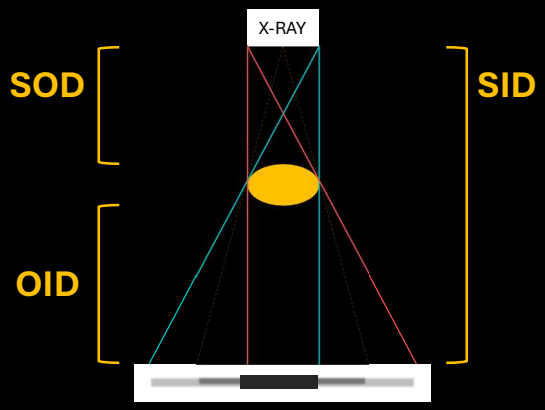
MAGNIFICATION

Magnification is the consequence of the divergent nature of the X-Ray beam. As a result, the object on the image is larger than the object in reality.

SID ↑
MAGNIFICATION ↓

OID ↑
MAGNIFICATION ↑

SOD ↑
MAGNIFICATION ↓



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MAGNIFICATION FACTOR (MF)

Describes how much magnification is present in the image.

MAGNIFICATION FACTOR = **IMAGE** SIZE / **OBJECT** SIZE

MAGNIFICATION FACTOR = **SID** / **SOD**

If the **magnification factor (MF)** is for example equal to 2; then the object within the image are 2X larger than the objects in reality.

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IMAGE QUALITY

DISTORTION

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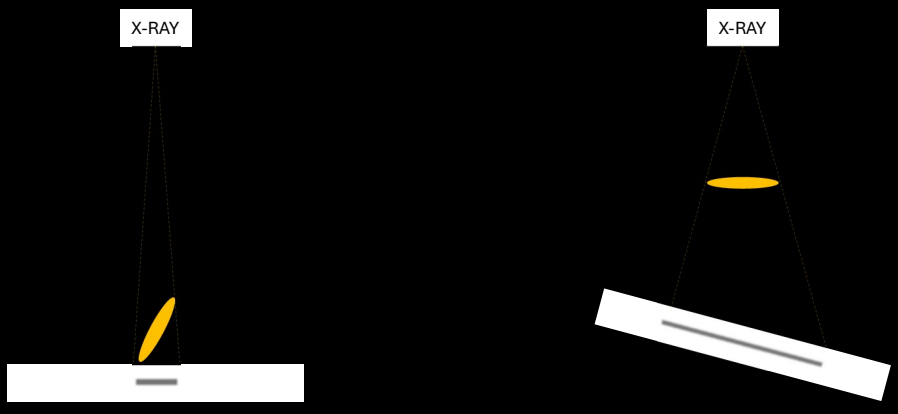
DISTORTION
A misrepresentation of the actual shape of the object in the image compared to the shape of the object in reality. (Elongated, Shortened, Stretched, Squeezed, ...)



SHORTENING
Occurs when the anatomy is not parallel to the image receptor

ELONGATION
Occurs when the X-Ray tube and image receptor are not perpendicular to each other

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QUALITY **ASSURANCE**

QA is a **process-oriented** approach. It encompasses the entire management system designed to ensure that the radiology department provides the best possible patient care. It focuses on preventing errors before they happen.

QUALITY **CONTROL**

QC is a **product-oriented** approach. It is a subset of QA that focuses specifically on the technical performance of the imaging equipment. **It involves physical tests to ensure the hardware is functioning within specified limits**.

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QUALITY **ASSURANCE**

QA is a **process-oriented** approach. It encompasses the entire management system designed to ensure that the radiology department provides the best possible patient care. It focuses on preventing errors before they happen.

_ **GOAL**

Ensure consistent production of high-quality images using minimum exposures to patients.

Examples: Staff training and retrospective image analysis.

QUALITY **CONTROL**

QC is a **product-oriented** approach. It is a subset of QA that focuses specifically on the technical performance of the imaging equipment. **It involves physical tests to ensure the hardware is functioning within specified limits**.

_ **GOAL**

Detect and correct equipment problems before they affect image quality of patient dose.

Examples: Exposure accuracy testing and phantom testing.

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QUALITY **ASSURANCE**

- **Orientation:**
  - Process (how things are done)
- **Scope:**
  - Broad (staff, admin, safety, equipment, …)
- **Primary Goal:**
  - Prevent errors and improve the system
- **Activities:**
  - Audits, training, protocol reviews, …

QUALITY **CONTROL**

- **Orientation:**
  - Product (the equipment and the image)
- **Scope:**
  - Narrow (technical equipment performance)
- **Primary Goal:**
  - Detect and fix equipment failures (or drifts)
- **Activities:**
  - Measurements, calibrations, testing, …

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QUALITY CONTROL TOOLS

Every radiology department is equipped with an arsenal of **quality control tools**. Some are used daily, some are weekly and some monthly or even yearly. The purpose of these tools is to **scientifically measure and verify equipment performance** and ensure it meets pre-determined standards.

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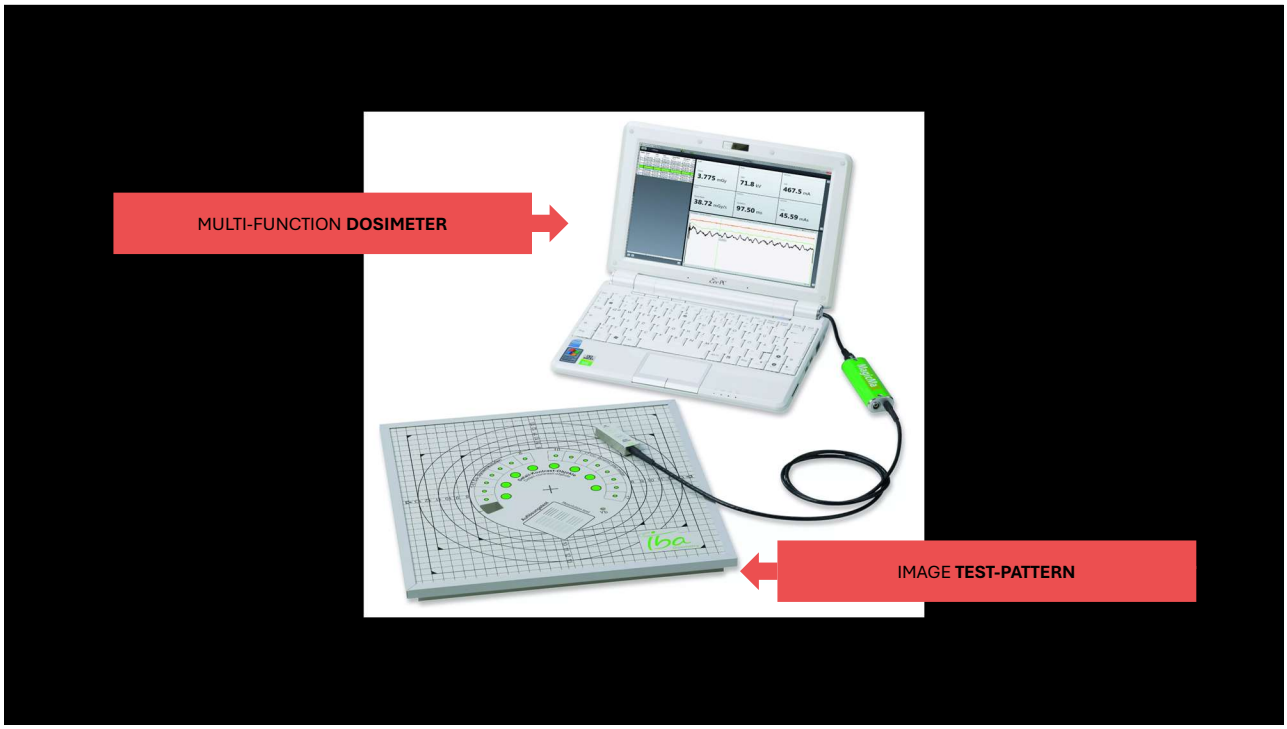

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MULTI-FUNCTION DOSIMETER
Can be used to verify kVp accuracy, mA accuracy, timer accuracy, dose, dose-rate and many other metrics.

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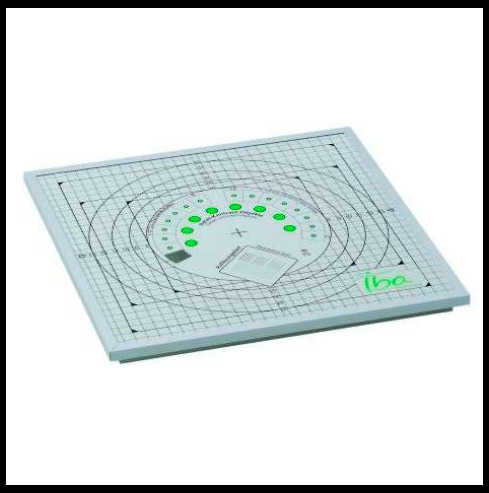
IMAGE TEST PATTERNS
Can be used to verify spatial resolution, contrast resolution, geometric distortion, collimation, ...



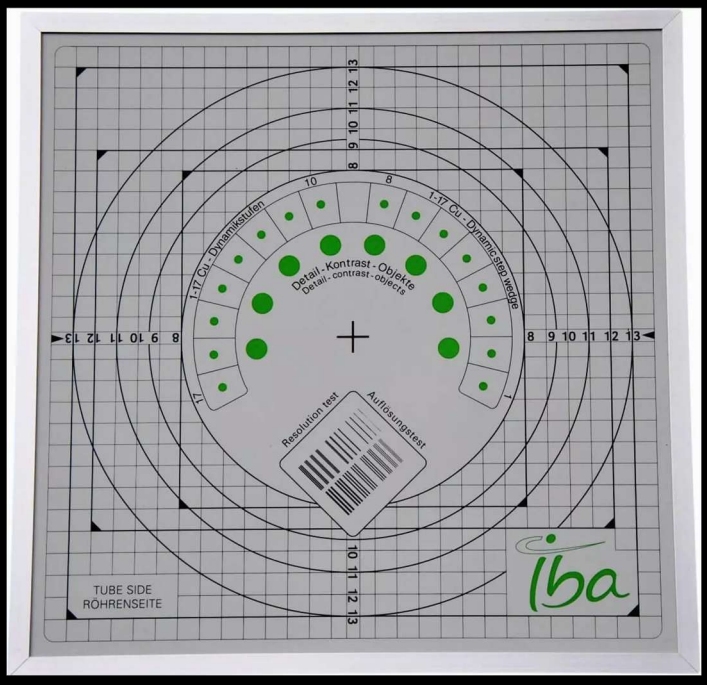


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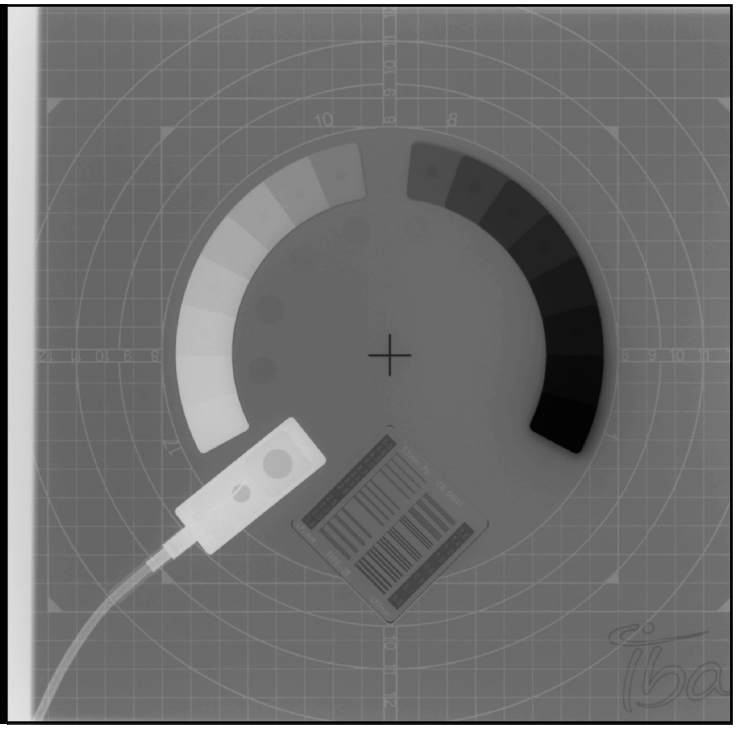
IMAGE TEST PATTERNS
Can be used to verify spatial resolution, contrast resolution, geometric distortion, collimation, ...



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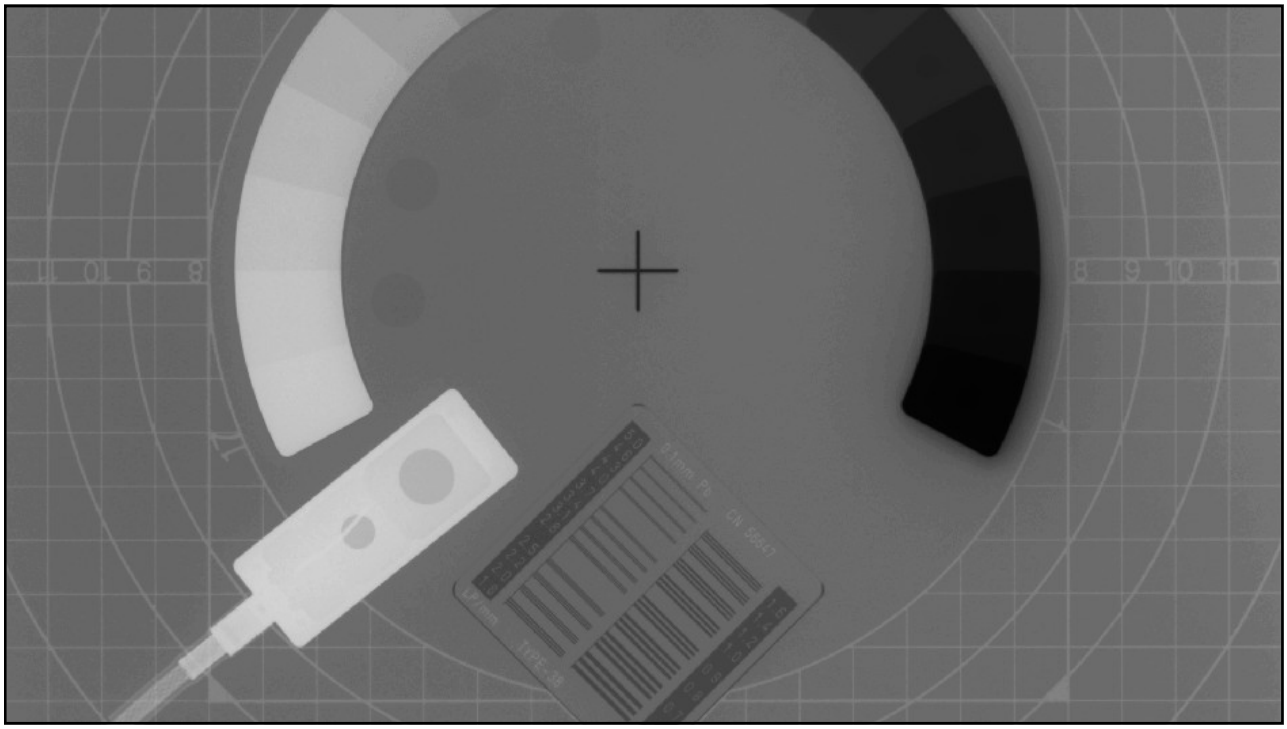

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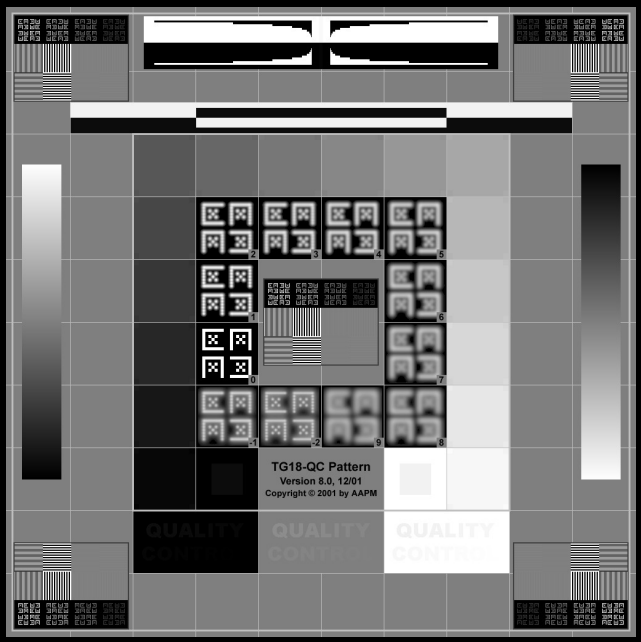
DISPLAY TEST PATTERNS
A test pattern to verify the performance of diagnostic display monitors.

LIGHT METER
A device to measure the light output of the diagnostic display monitor.



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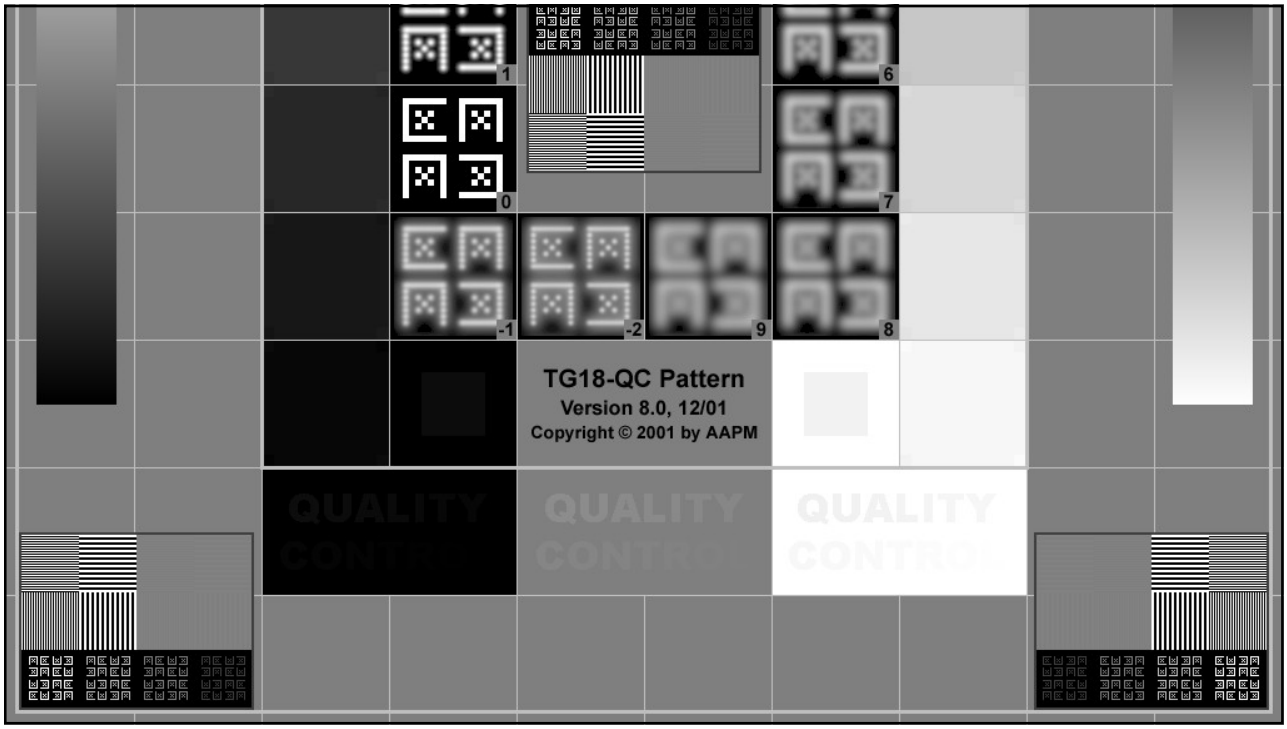
TG18-QC Pattern
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QUALITY
CONTROL

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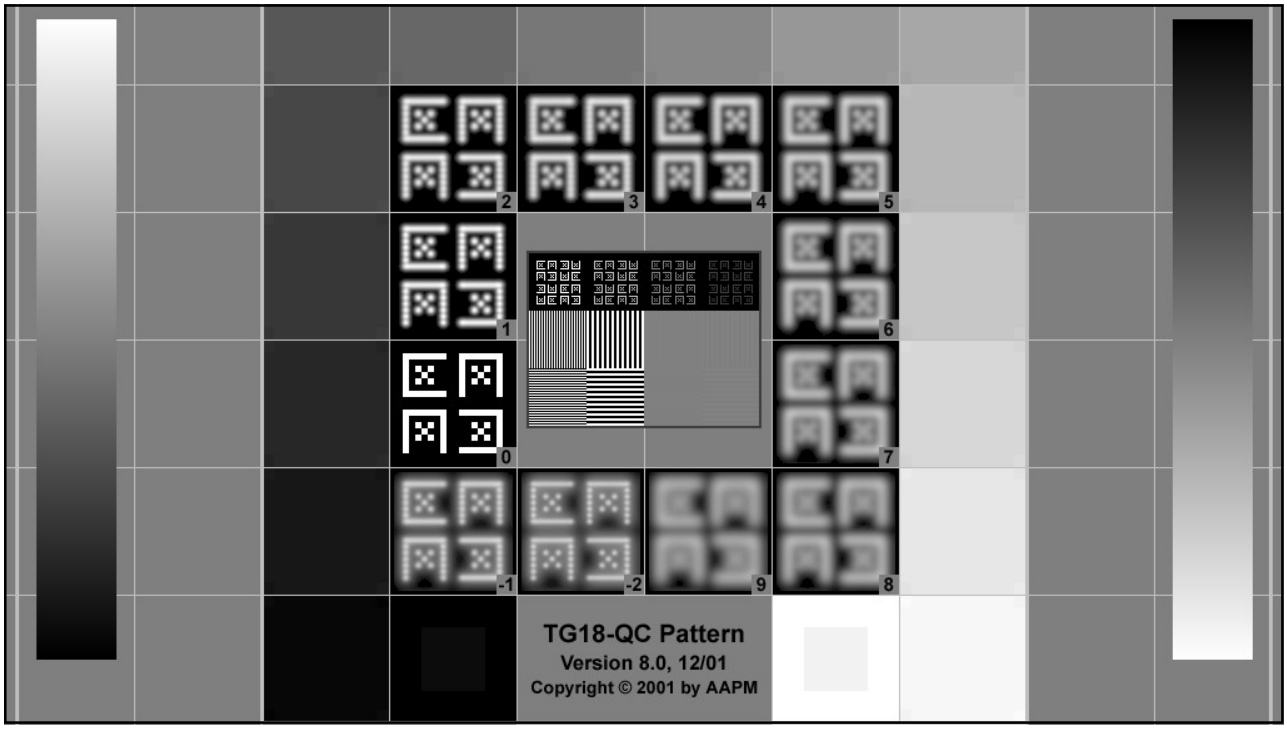
TG18-QC Pattern
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ANTRHOPOMORPHIC PHANTOMS
In radiology, an anthropomorphic phantom is a specialized test object designed to mimic the human body's anatomical shape, tissue composition, and radiation attenuation characteristics. They are used for dosimetry, image quality assessment, training, and protocol optimization.

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