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Phantoms, Dose and Image Duality

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Phantoms, dose and image quality

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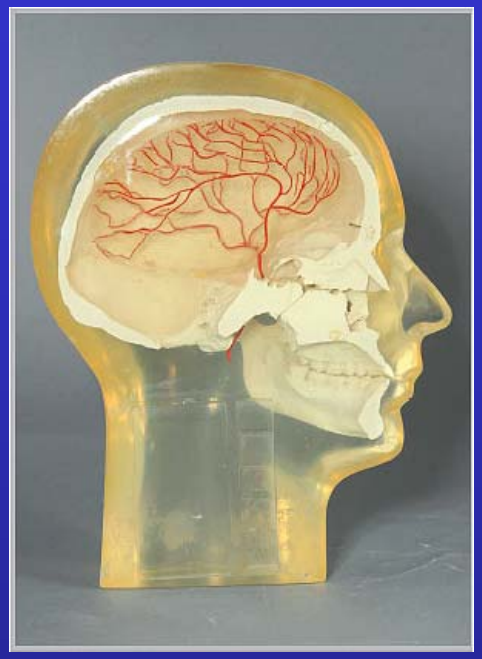
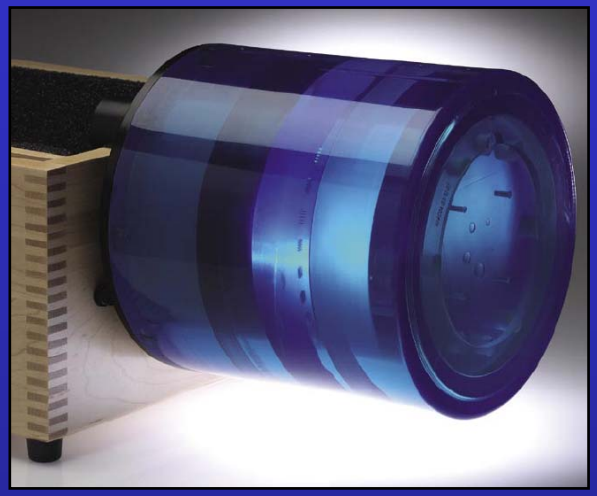
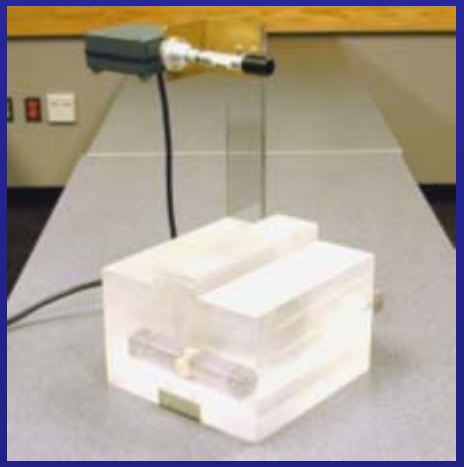
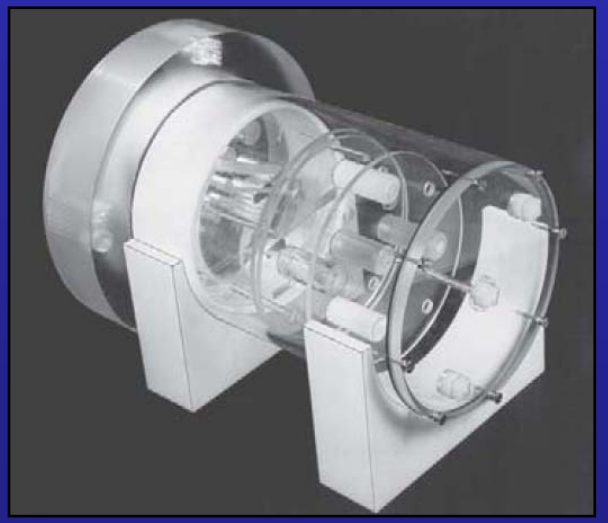
Phantoms

Test Objects



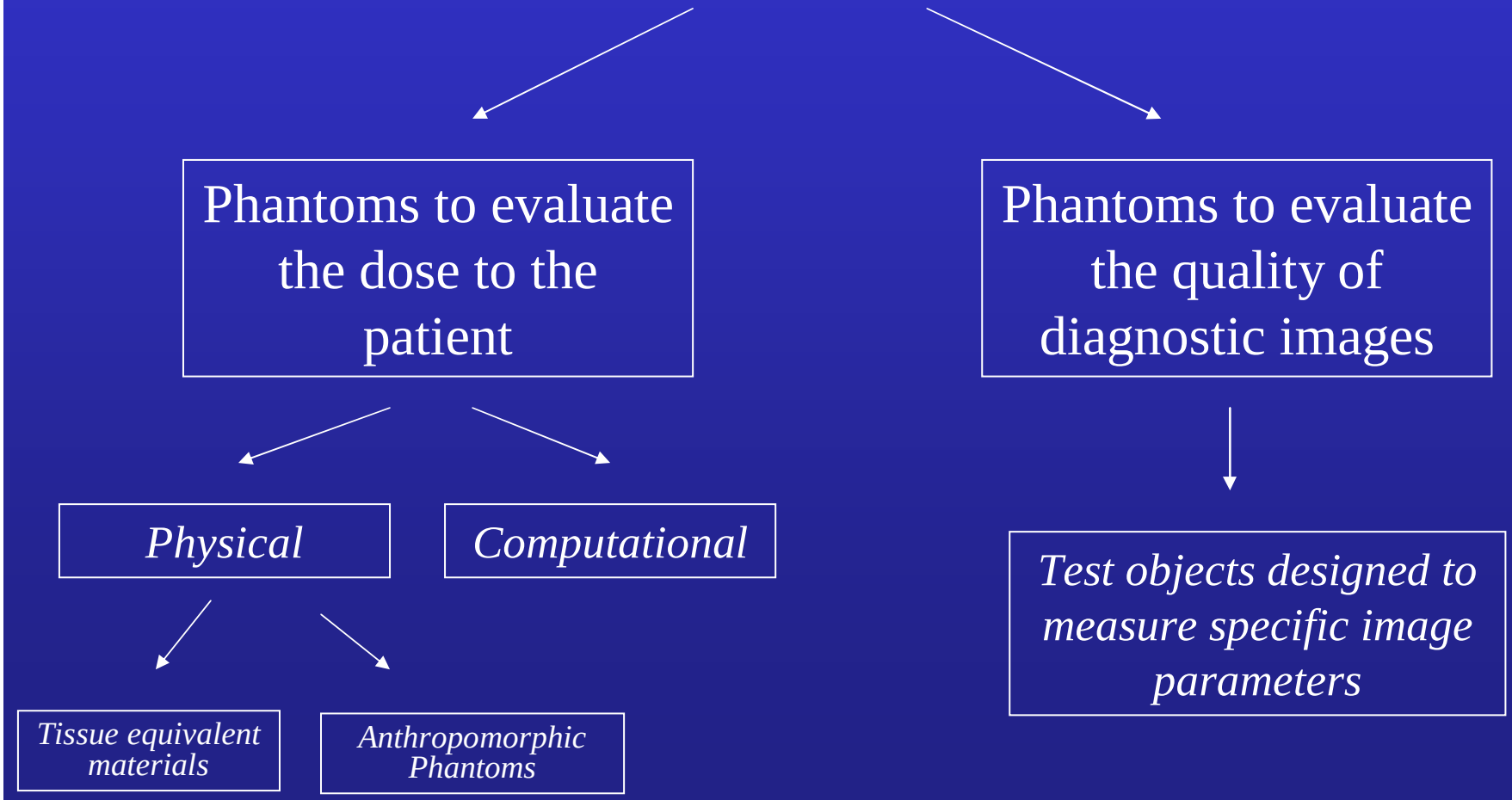






Types of phantoms

Main categories

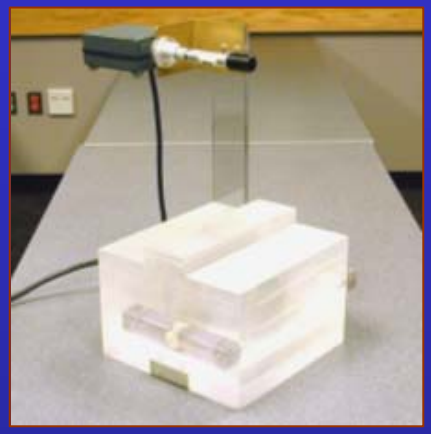


Phantoms to evaluate the dose to the patient

Examples of Physical Phantoms

PMMA mammography phantom

CDRH abdomen/lumbar spine phantom



PMMA CT phantom

Phantoms to evaluate the dose to the patient

Suitable materials

Water

- *Pro* ➢ similar energy dependence to a patient
- *Cons* ➢ heavy and difficult to fill

PMMA

- *Pro* ➢ easy to find and to use
- *Cons* ➢ some energy dependence

Aluminium and copper

- *Pro* ➢ thin and easy to positioning
- *Cons* ➢ significant energy dependence

Phantoms to evaluate the dose to the patient

Anthropomorphic Phantoms

Visual analysis

Tissue-equivalent materials containing abdominal and pelvic organs: stomach, gall bladder, urinary bladder, kidneys, rectum and sigmoid flexure

Measurements

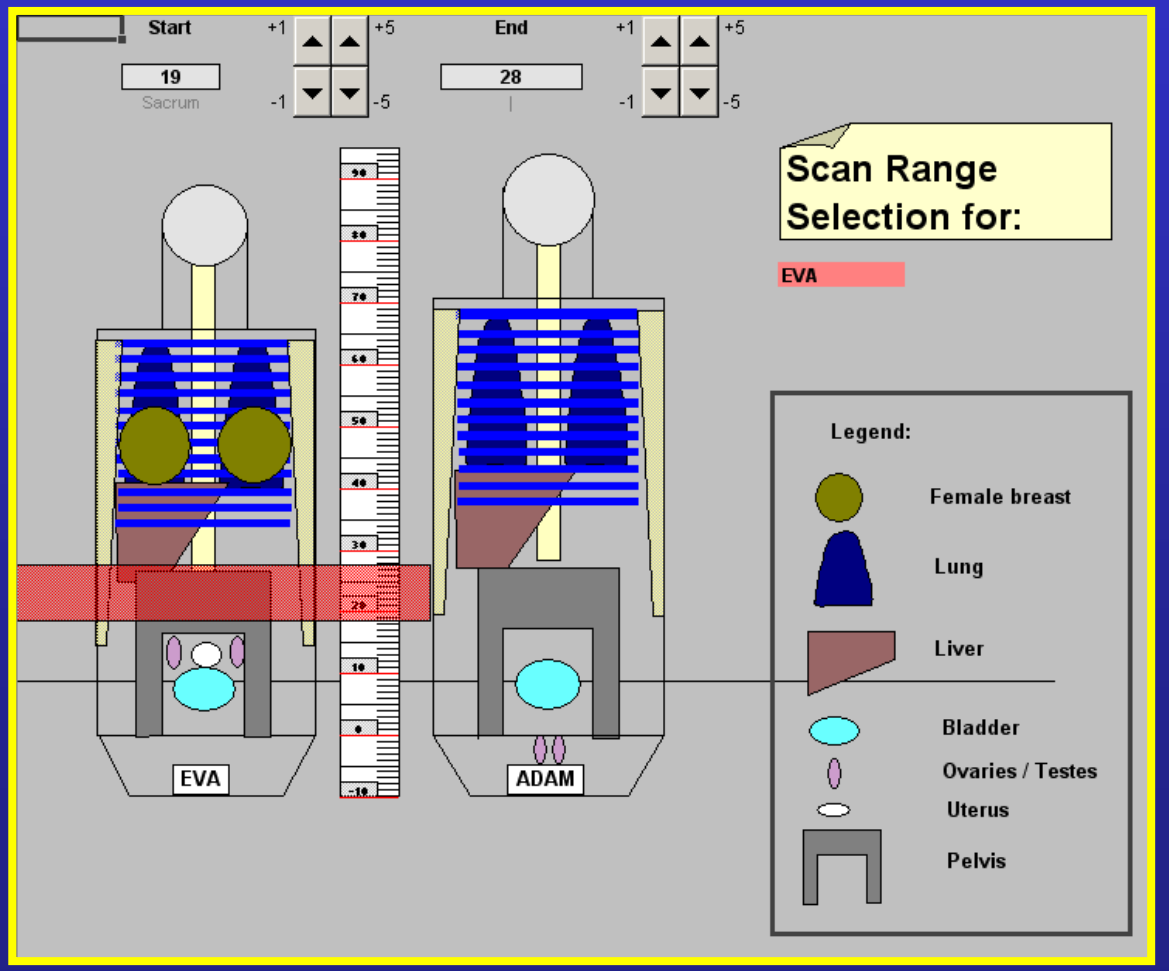
Anthropomorphic Phantom made by slices with holes where can be inserted TLD dosimeters to obtain well defined map of internal dosimetry

Phantoms to evaluate the dose to the patient

Computational Phantoms

Example of mathematical phantom "Adam" and "Eve".

From "CT-Expo": a tool for dose evaluation in Computed Tomography



Dose and image quality

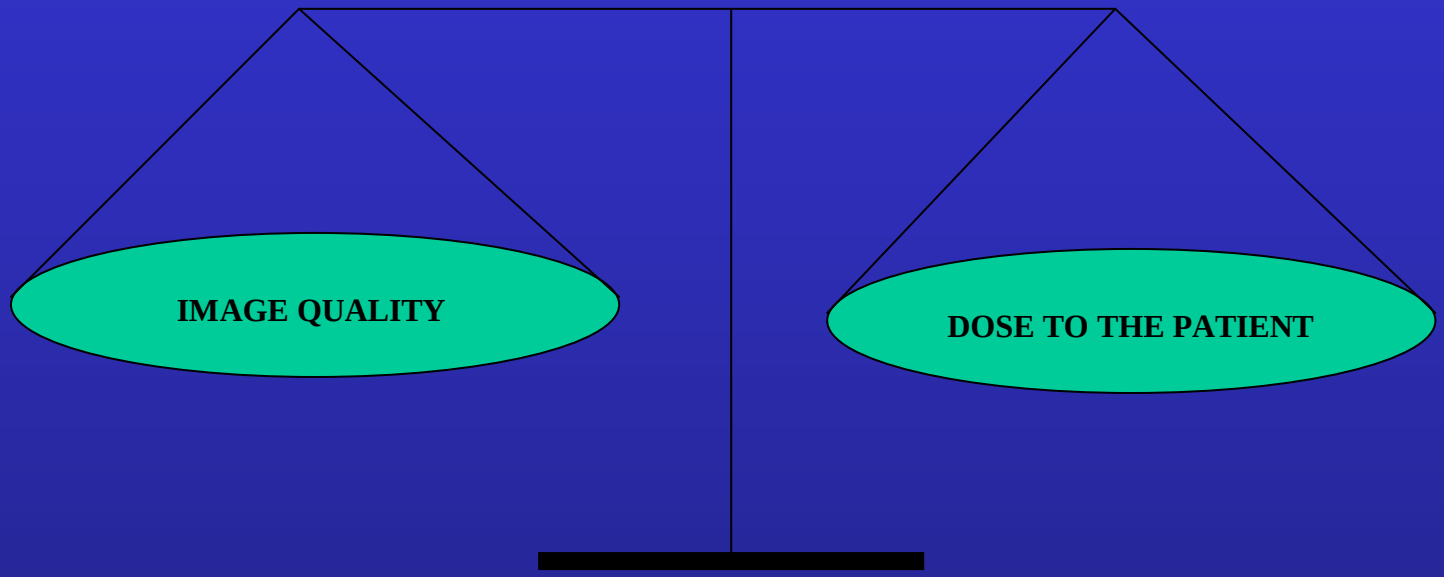


Image quality must be related to dose

The increment of the Dose (e.g. higher tube loading) improve image quality

Phantoms to evaluate the image quality

Design to …

…. measure specific parameters affecting the image quality

…. be imaged in the specific equipment submitted to evaluation

Image quality

Main parameters affecting image quality

- **High contrast spatial resolution**
- **Low Contrast Detectability**
- **Noise**

Spatial Resolution

DEFINITION

The ability to distinguish between two closely spaced objects on an image

NOISE

Affect the spatial resolution for low contrast detail

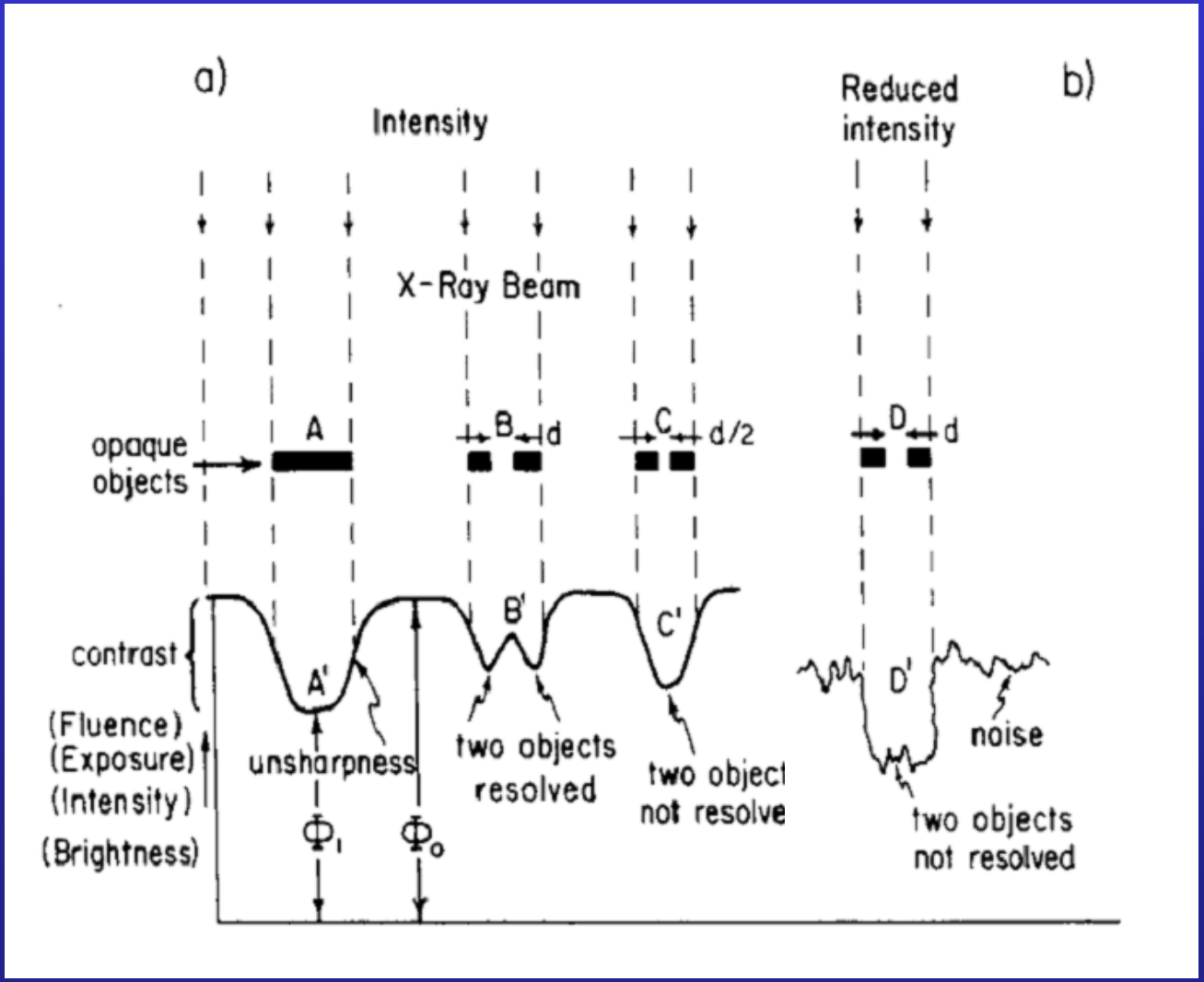


Image Contrast

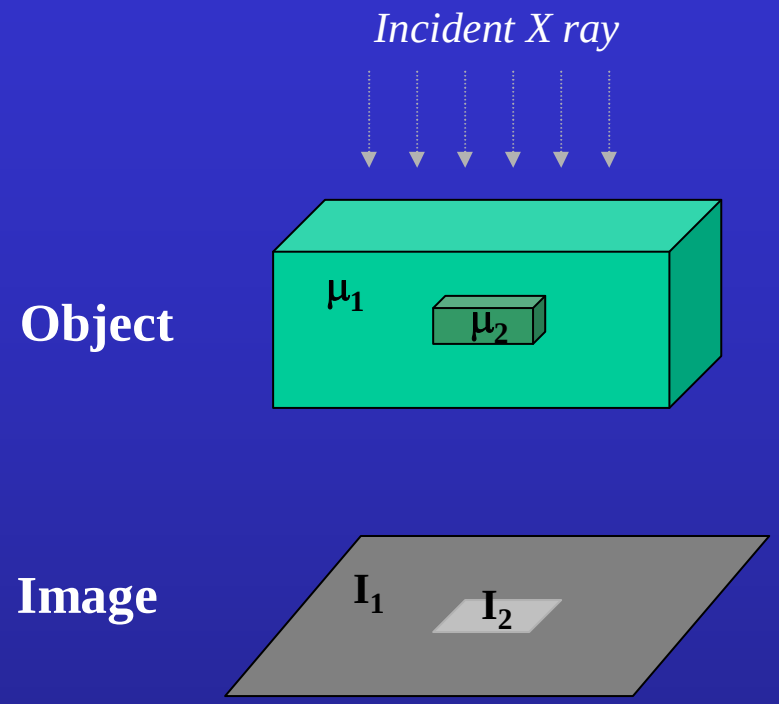


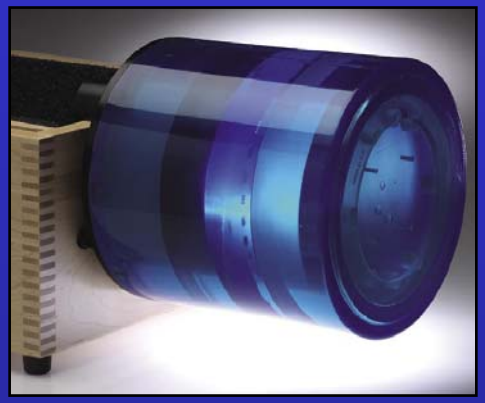
Image Contrast can be quantified as the difference in percent between the image of an objet and the background

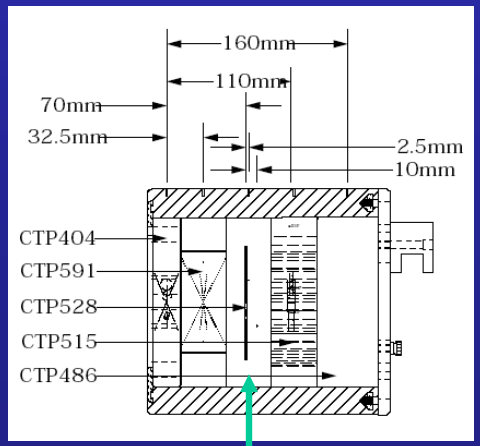
C% = [(I1-I2) / I1] * 100

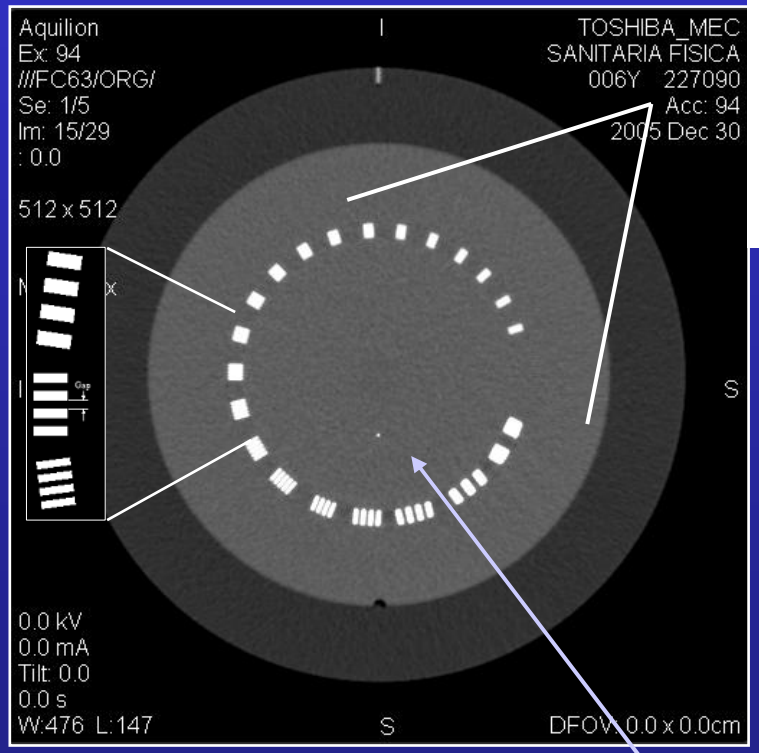
Phantoms for the measurement of High Contrast Spatial Resolution

Computed Tomography

Catphan 600 phantom







Increasing spatial frequency bars

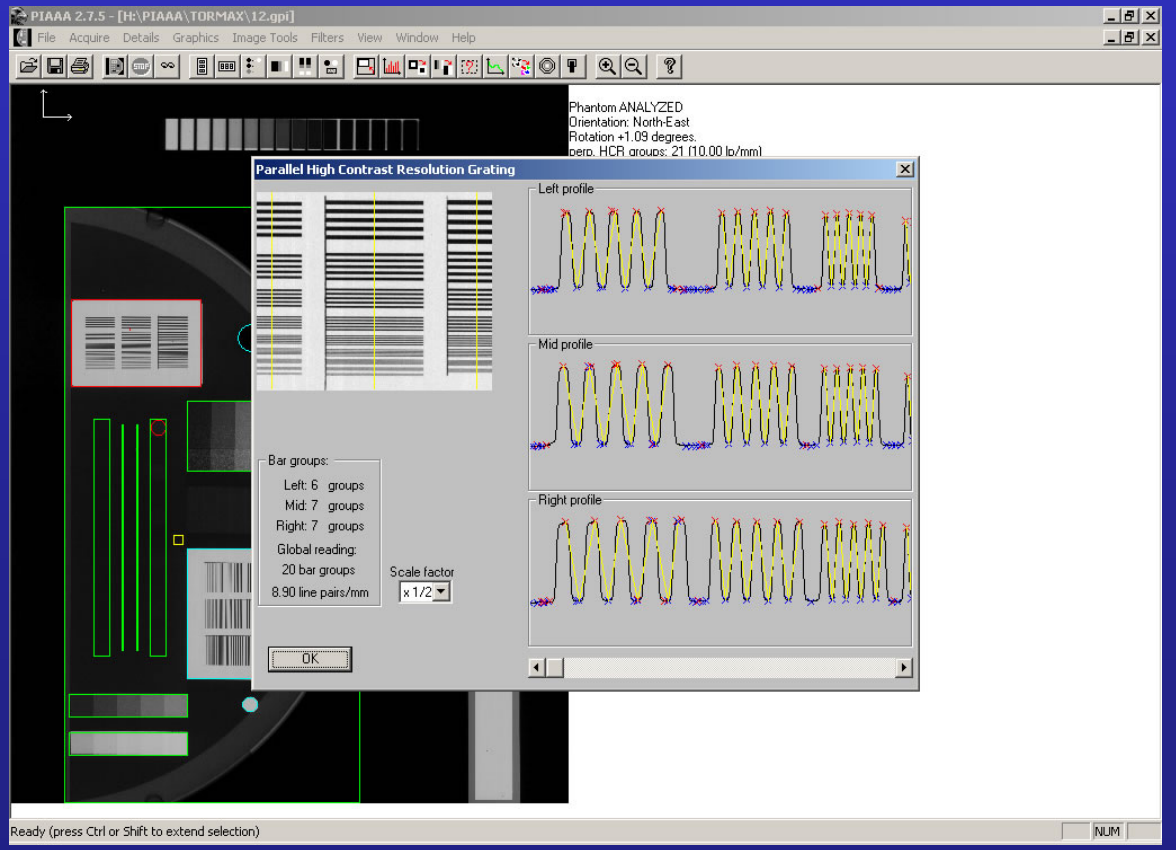
Line Pair/cm	Gap Size	Line Pair/cm	Gap Size
1	0.500 cm	11	0.045 cm
2	0.250 cm	12	0.042 cm
3	0.167 cm	13	0.038 cm
4	0.125 cm	14	0.036 cm
5	0.100 cm	15	0.033 cm
6	0.083 cm	16	0.031 cm
7	0.071 cm	17	0.029 cm
8	0.063 cm	18	0.028 cm
9	0.056 cm	19	0.026 cm
10	0.050 cm	20	0.025 cm
		21	0.024 cm

Bead Point Source
tungsten carbide
diameter 0.28mm

Phantoms for the measurement of High Contrast Spatial Resolution

Mammography

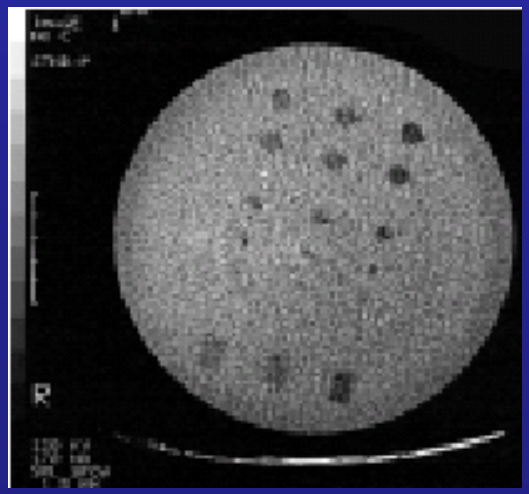
Leeds TOR MAX phantom

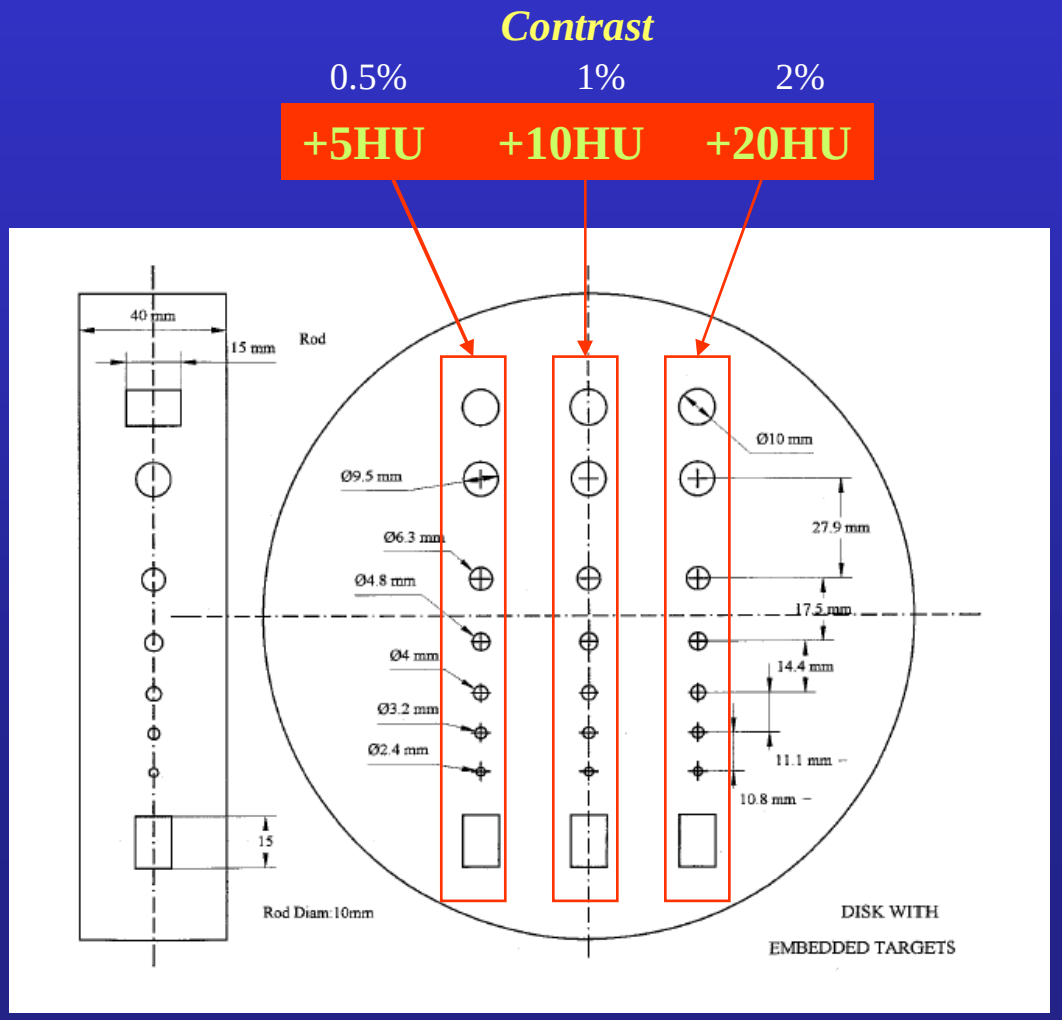


Phantoms for the measurement of Low Contrast Detectability

Computed Tomography

CIRS Helical CT Phantom - Model 061

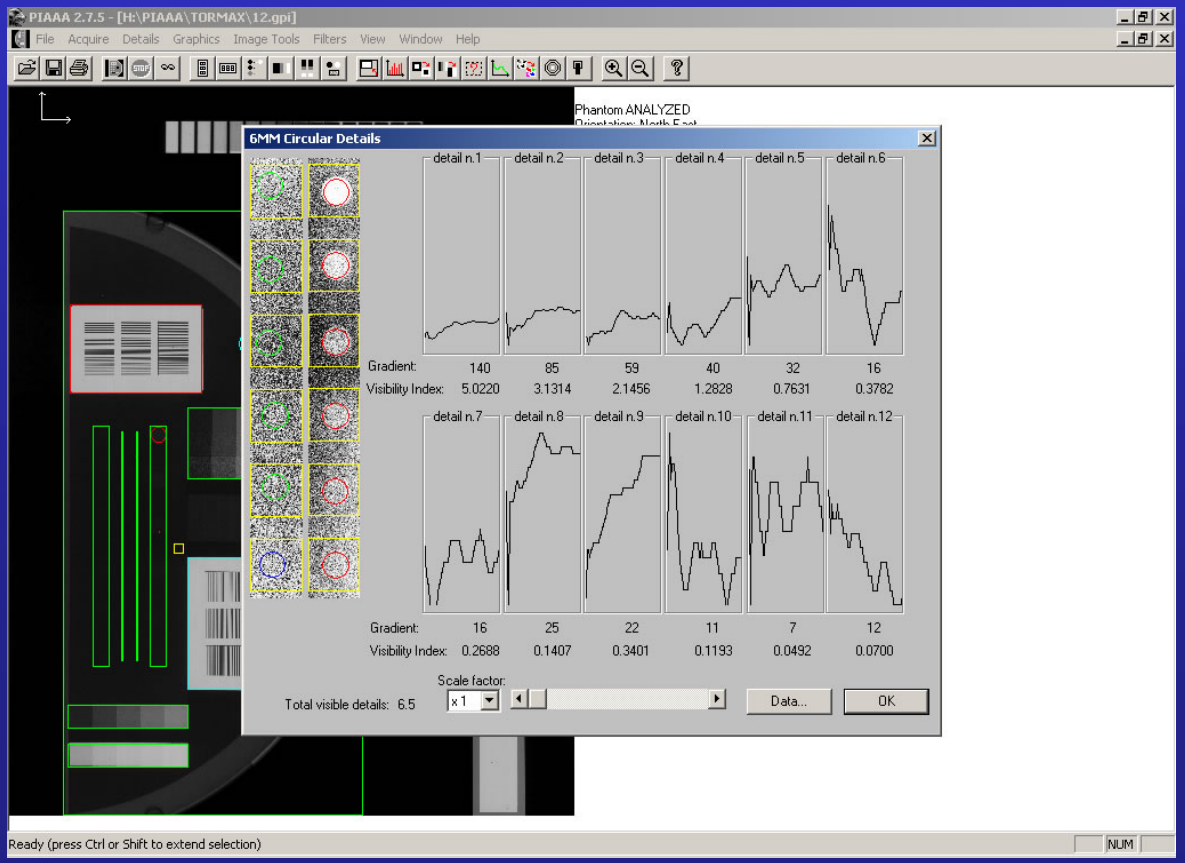




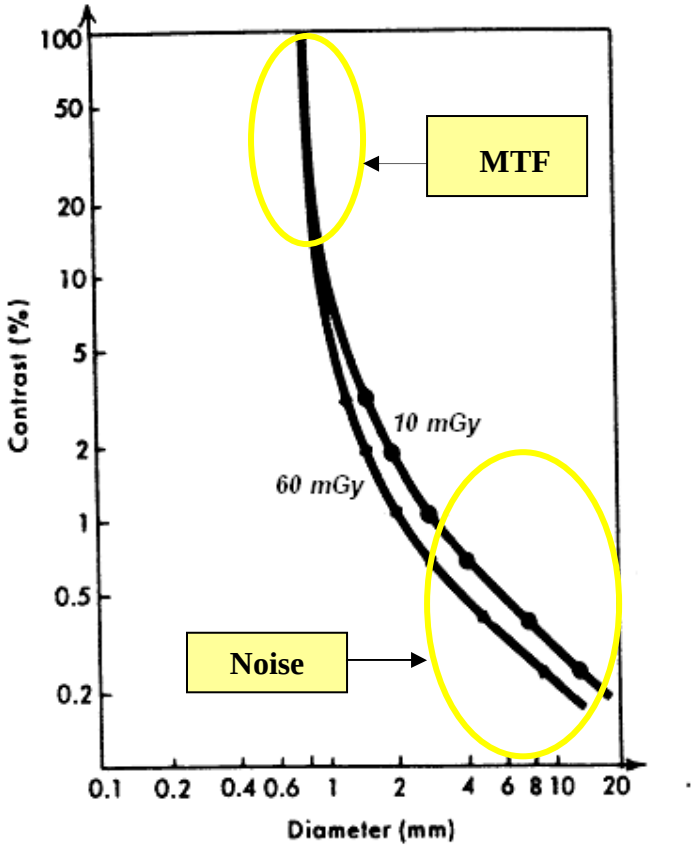
Phantoms for the measurement of Low Contrast Detectability

Mammography

Leeds TOR MAX phantom



Low Contrast Detectability : Contrast Detail Curve



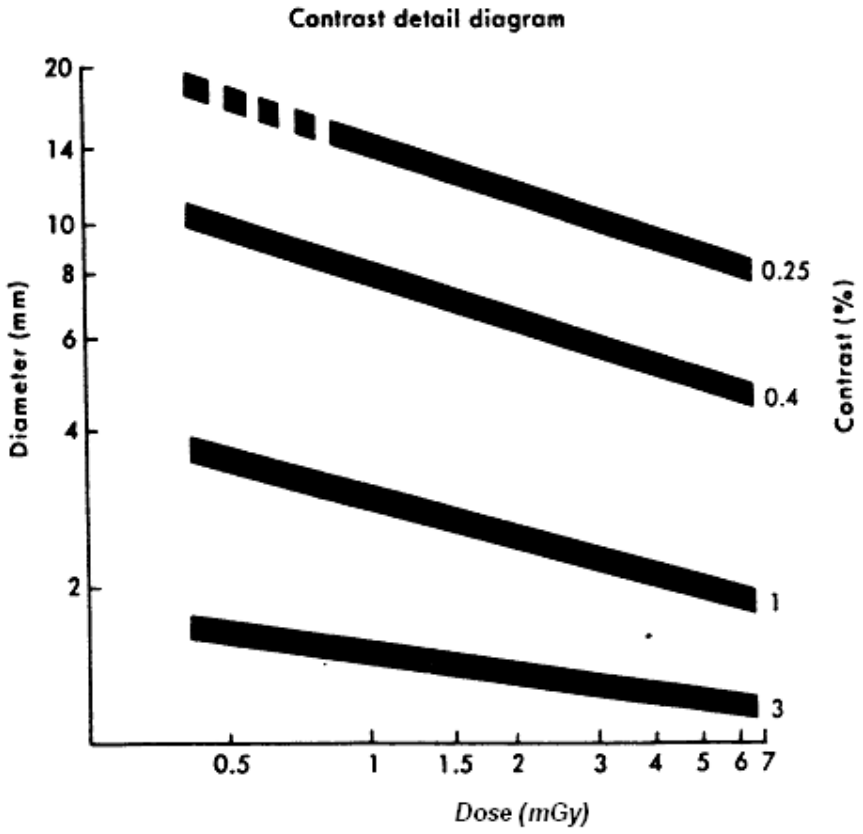
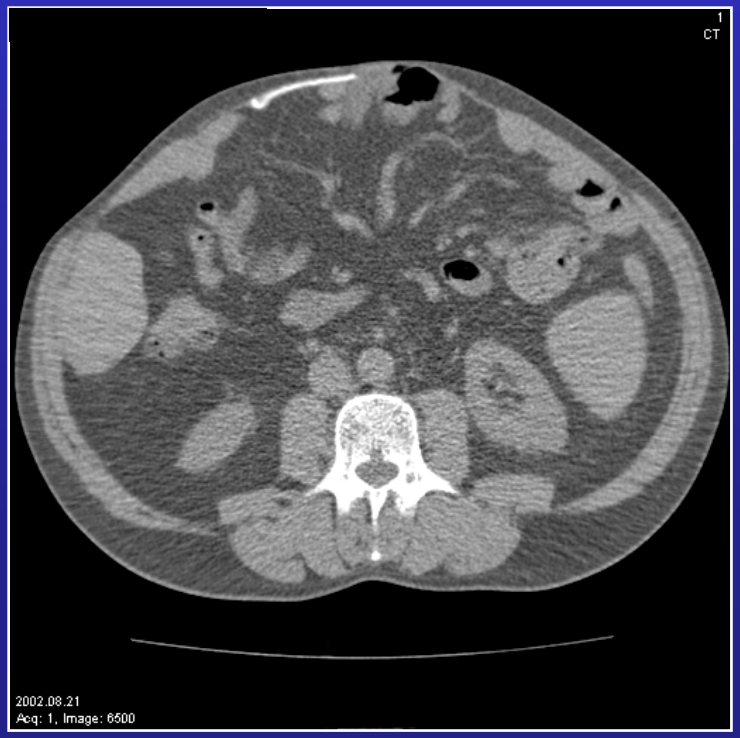


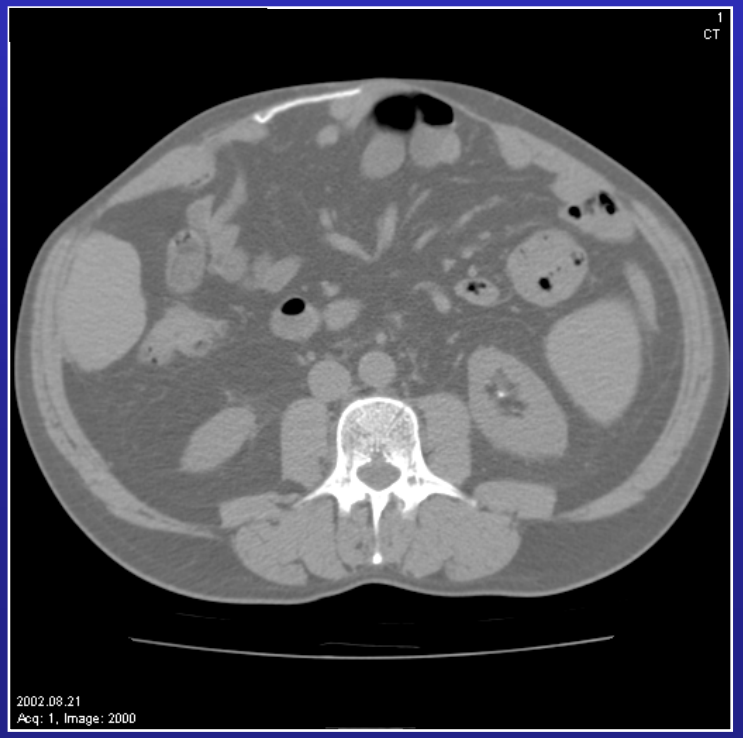
Image Noise

Noise decrease as tube loading increase

$$\text{Noise} \propto \frac{1}{\sqrt{\text{no. of incident photons}}}$$



50 mA/sec



250 mA/sec

Noise measurement

Uniform materials Test Objects

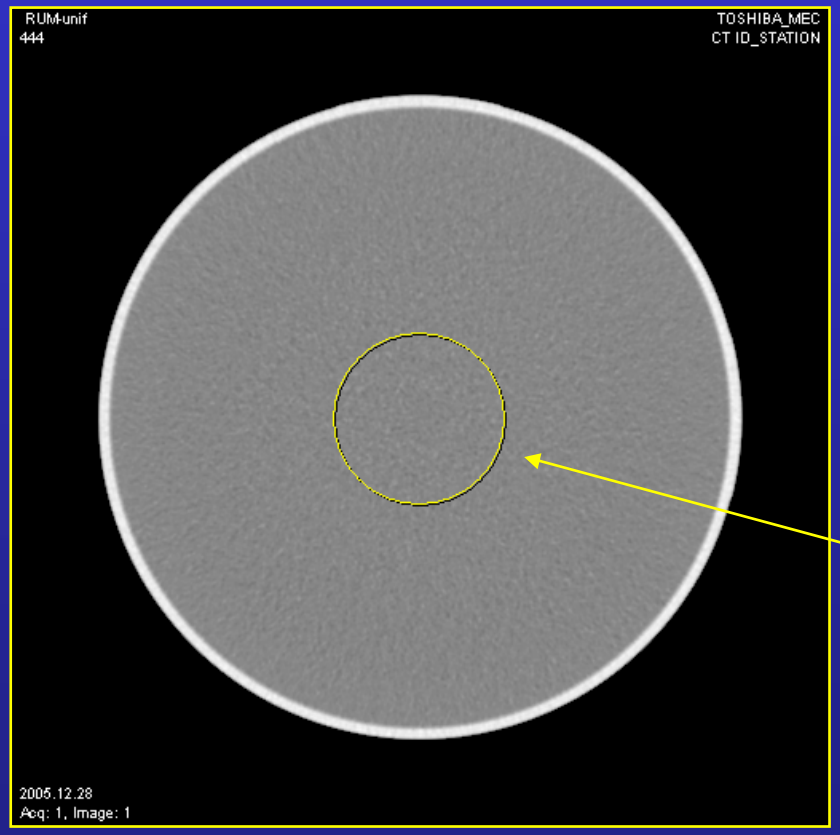
Water, PMMA, Acrylic, ……

The standard deviation of the image represent a suitable parameter to estimate the noise

$$\text{Image Standard Deviation} \propto \frac{1}{\sqrt{\text{no. of incident photons}}}$$

Noise measurement

-- WATER PHANTOM --



ROI
Region Of Interest