Development of Complex Curricula for Molecular Bionics and Infobionics Programs within a consortial* framework**

Consortium leader

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Consortium members

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**Molekuláris bionika és Infobionika Szakok tananyagának komplex fejlesztése konzorciumi keretben

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BIOMEDICAL IMAGING

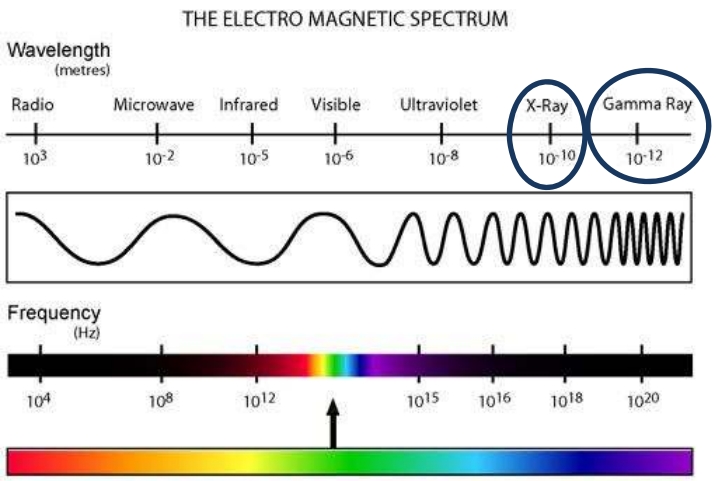
(Orvosbiológiai képalkotás)

INTRODUCTION AND X-RAY

(Bevezetés és röntgenismereti alapok)

GYÖRGY ERŐSS, ZOLTÁN VIDNYÁNSZKY

The electromagnetic spectrum:



- a continuum of all electromagnetic waves arranged according to frequency and wavelength
- electromagnetic energy passes through space at the speed of light in the form of sinusoidal waves

Important waves in the medical imaging technics:

X-rays are very energetic, and are used in X-ray machines to take pictures of bones etc.

Gamma rays are the most energetic light waves found on the electromagnetic spectrum. Gamma rays are used in radiation cancer therapy and some kinds of diagnostic imaging such as PET scans.

Main interactions with matter:

- X-ray: Excitation and ejection of core atomic electrons, Compton scattering (for low atomic numbers)
- Gamma rays: Energetic ejection of core electrons in heavy elements, Compton scattering (for all atomic numbers), excitation of atomic nuclei, including dissociation of nuclei

Biological Imaging vs. The Eye

	Eye	Biological Imaging
Spatial resolution	~0.1 mm	~1 nm
Temporal resolution	~100 ms	~20 ms
Sensitivity	~100 photons	~1 photon
Wavelength range	400 – 700 nm	10^{-13} – 1 m

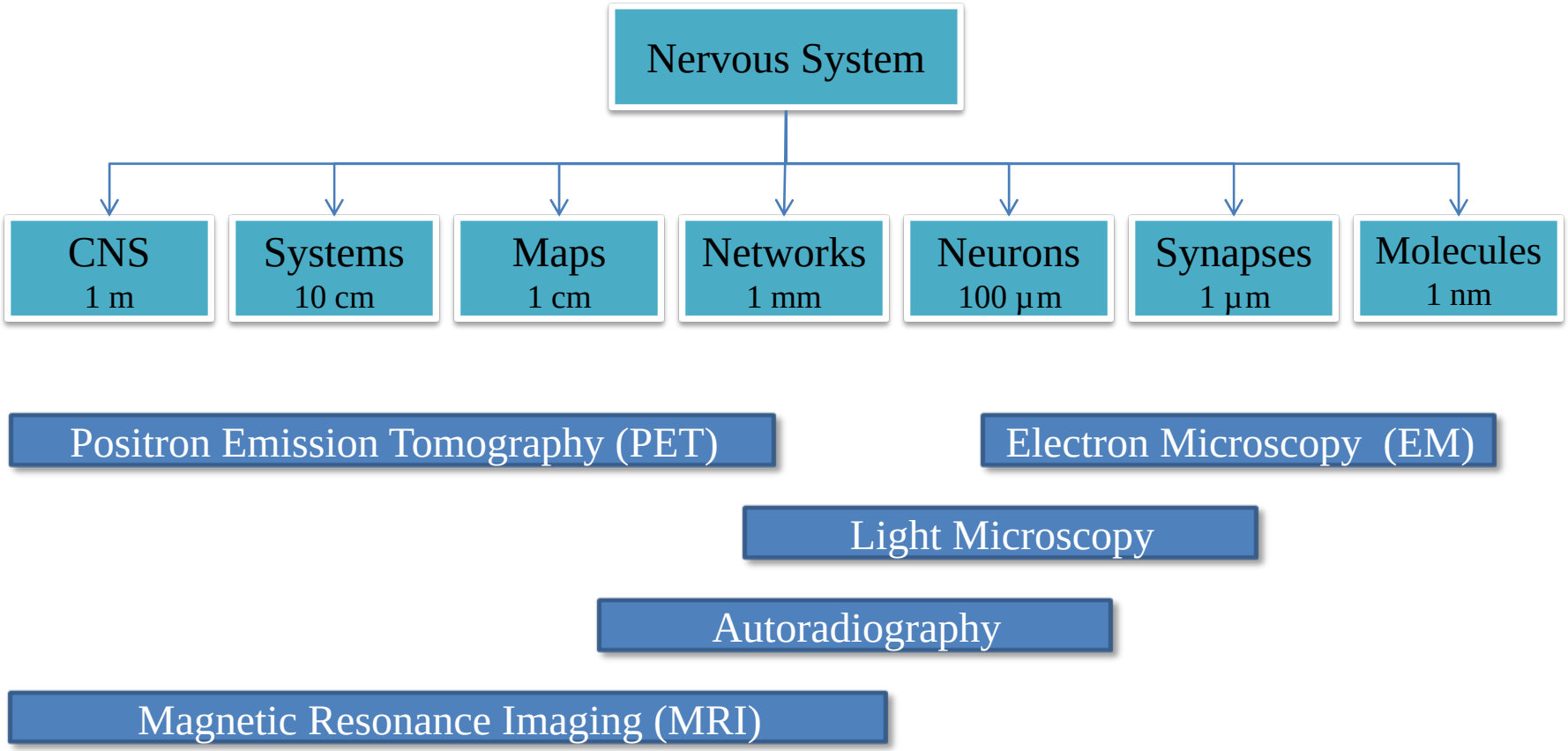
Biological imaging can:

- watch processes too rapid to be perceived
- see objects too small for the eyes to see
- see radiations too faint for the eye or that the eye is not sensitive to
- see inside living objects

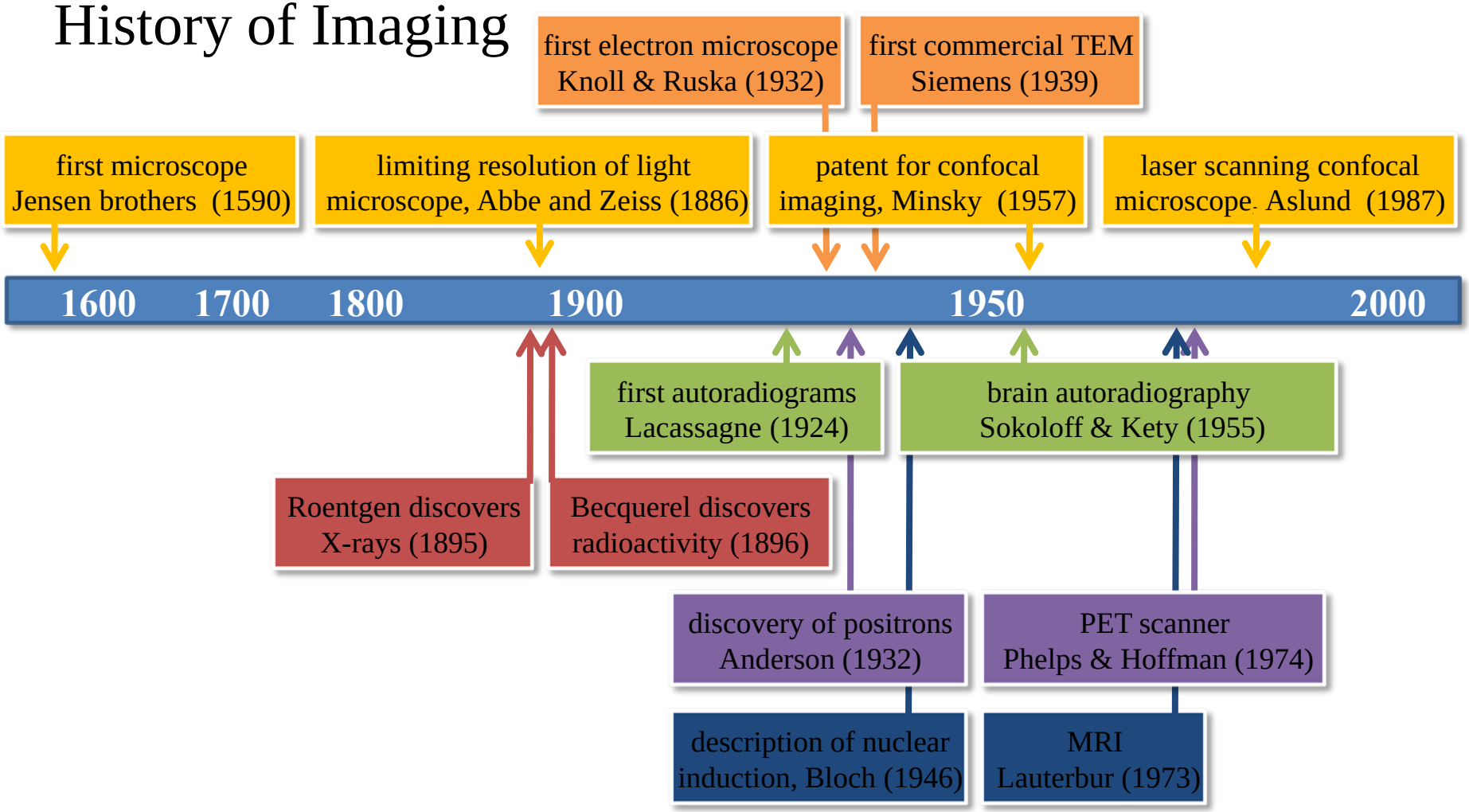
Ideal Biological Imaging Technique

- 1 nm spatial resolution
- 1 ms temporal resolution
- no ionizing radiation
- endogenous source of contrast
- in vivo – no restraint or anesthesia
- shows structure and function
- see everywhere inside the body
- low cost
- ease of use

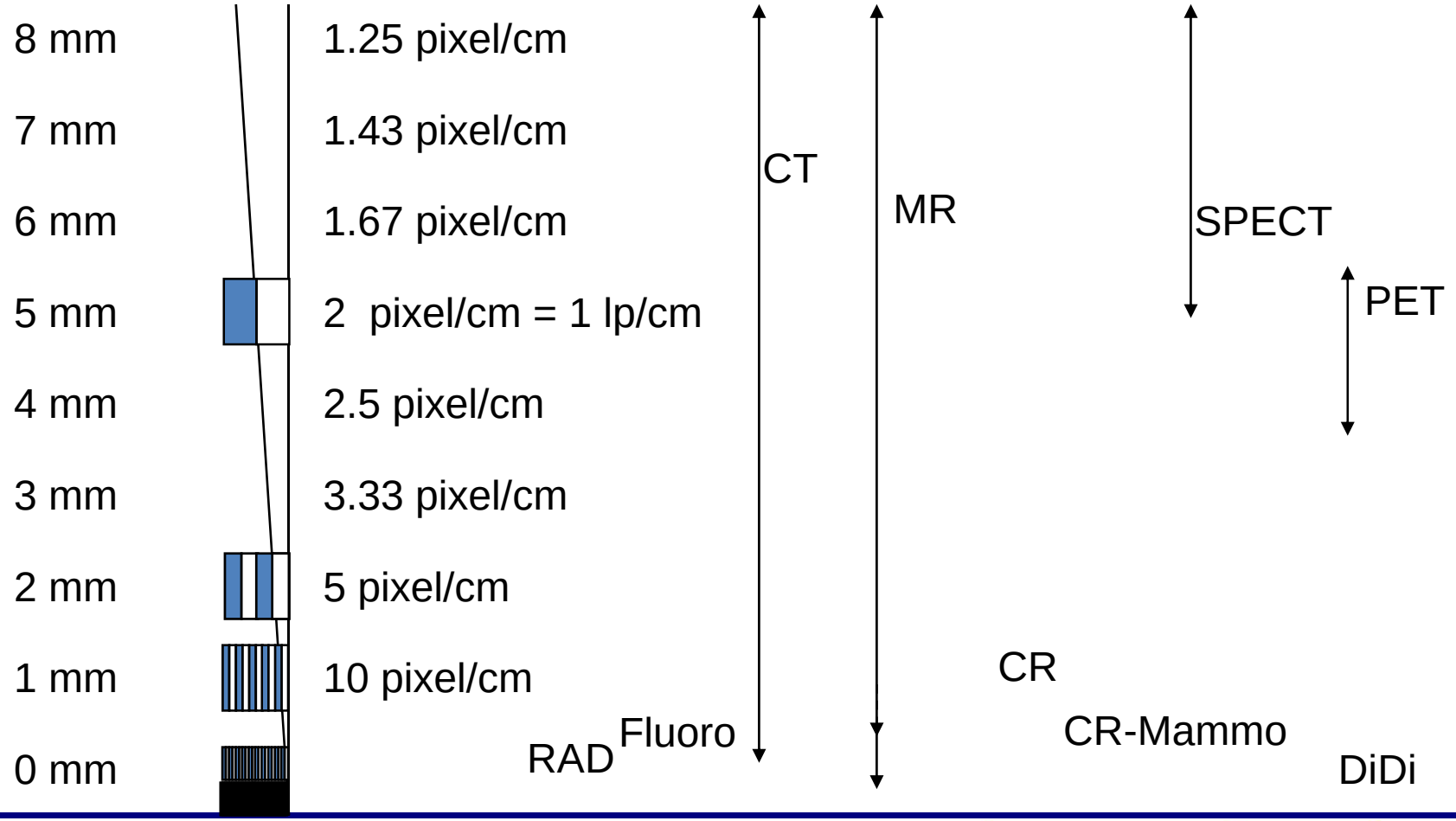
Spatial Scales in the Central Nervous System



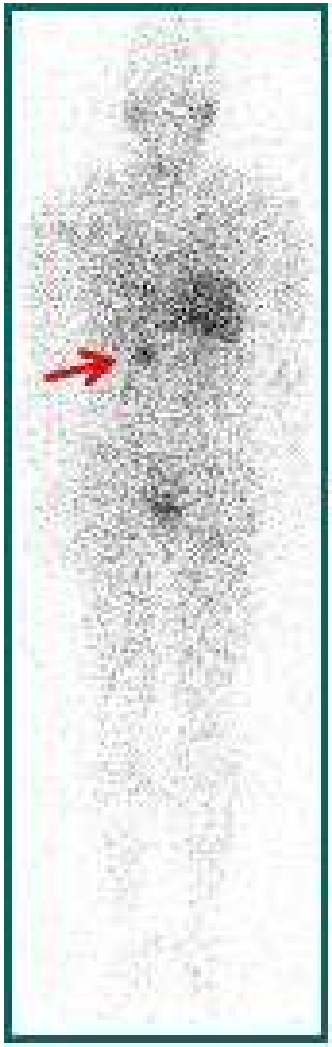
History of Imaging



Resolution of different imaging modalities

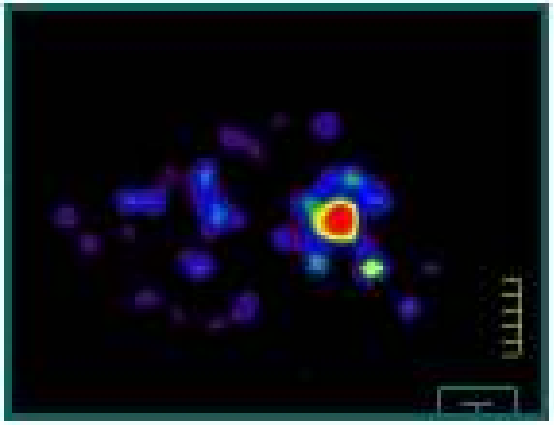


Biomedical Imaging: Introduction and X-ray



CT

SPECT-CT



SPECT

SPECT- low resolution functional image
CT – high resolution anatomical image

Classification of Different Imaging Methods

External signal:

- Ultrasound
- Conventional X-ray:
  - Radiography
  - Fluoroscopy
- Digital X-ray:
  - Computed Radiography
  - Direct Digital systems
  - CT: Computed Tomography
- MR(I): Magnetic Resonance Imaging

Internal signal:

- Thermography (-), etc.
- Nuclear Medicine
  - SPECT: Single Photon Emission Computed Tomography
  - PET: Positron Emission Tomography

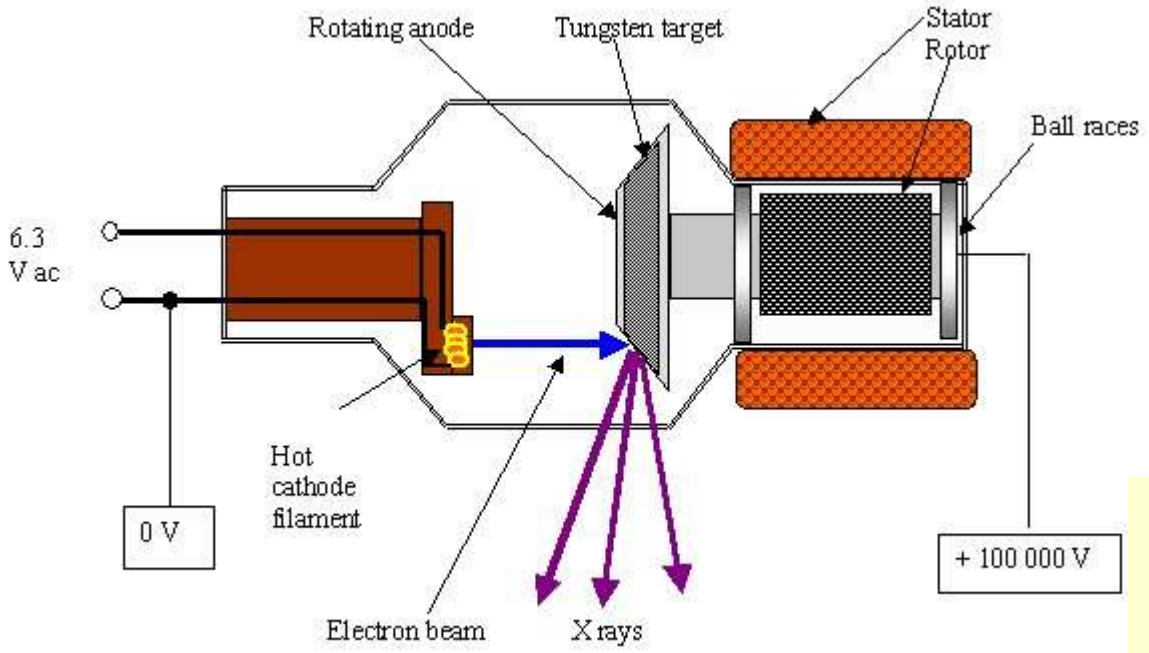
Wilhelm Conrad Röntgen

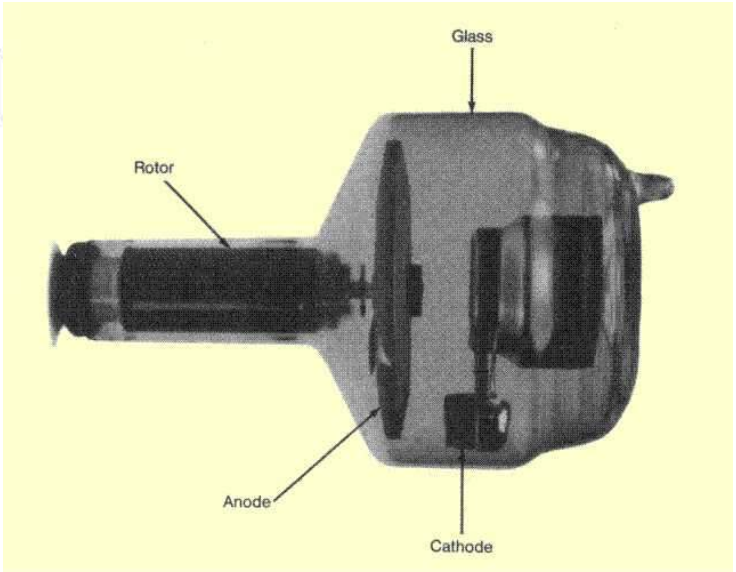
German physicist

March 27, 1845 - February 10, 1923

Accidentally discovered X rays while experimenting with cathode rays emitted from a Crookes tube,

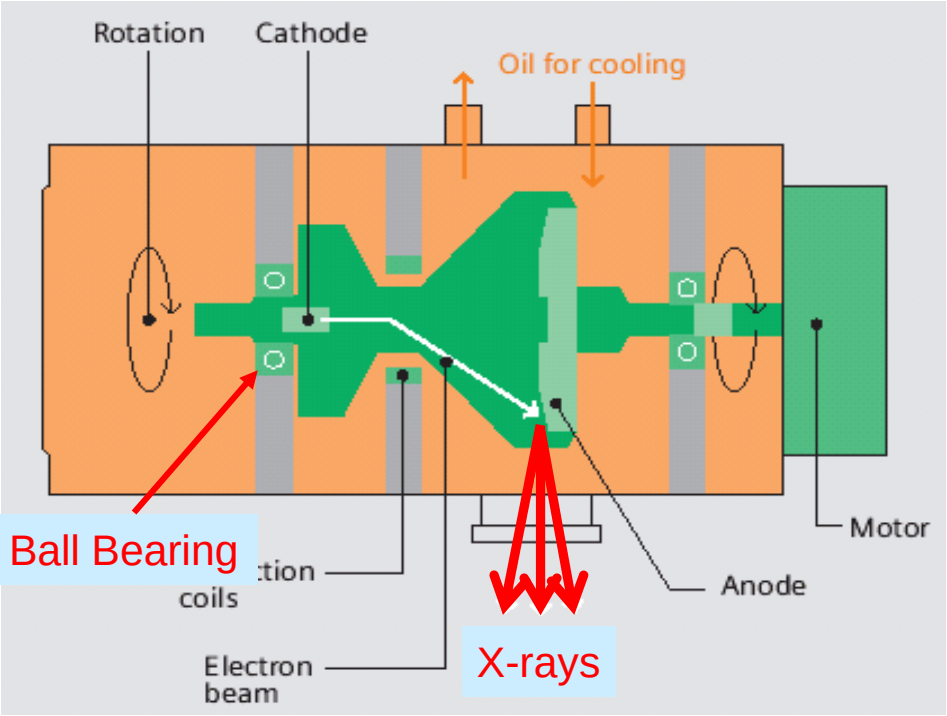
winning the 1901 Nobel Prize in physics for this accomplishment

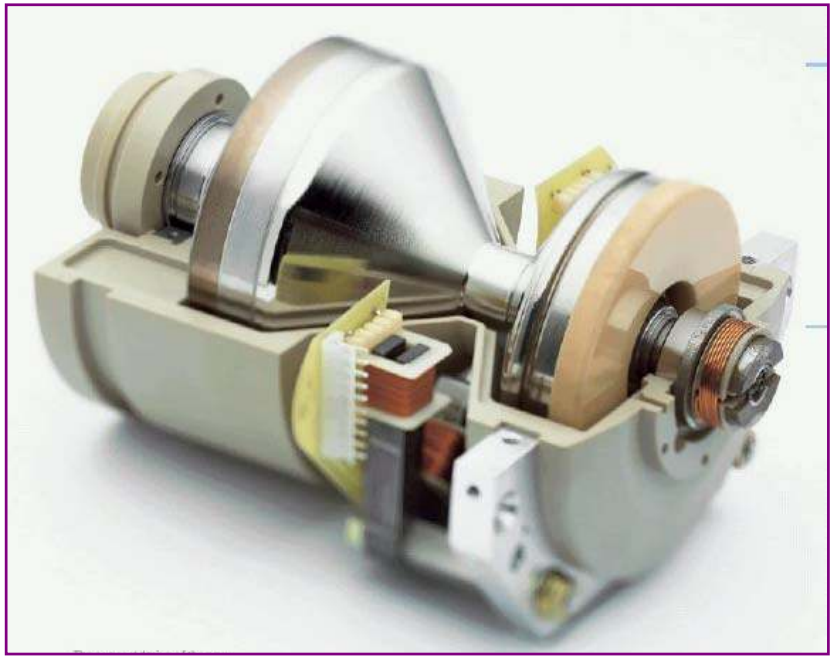




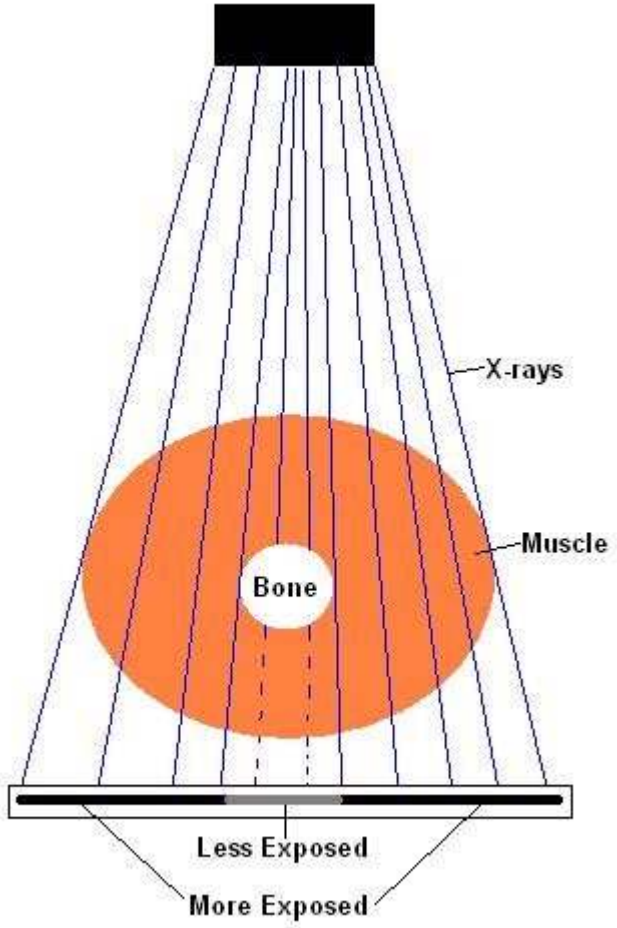
Structure of an x-ray tube with rotating anode

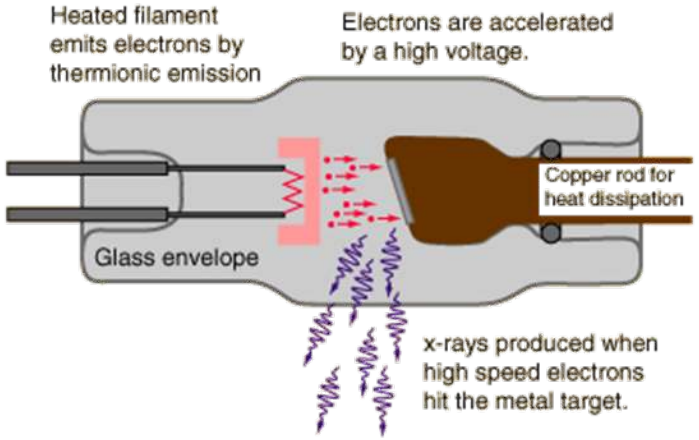
Special structure of high performance x-ray tube for CTs

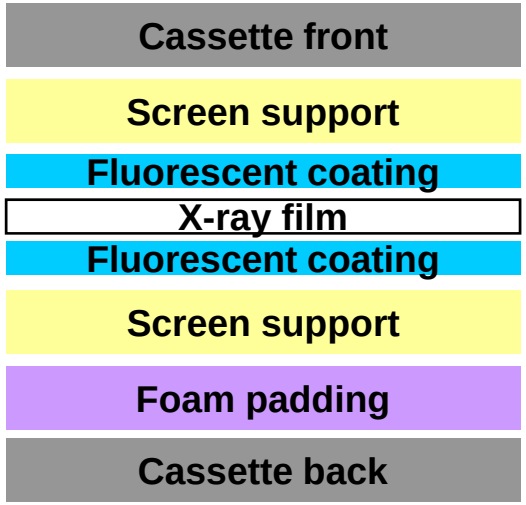




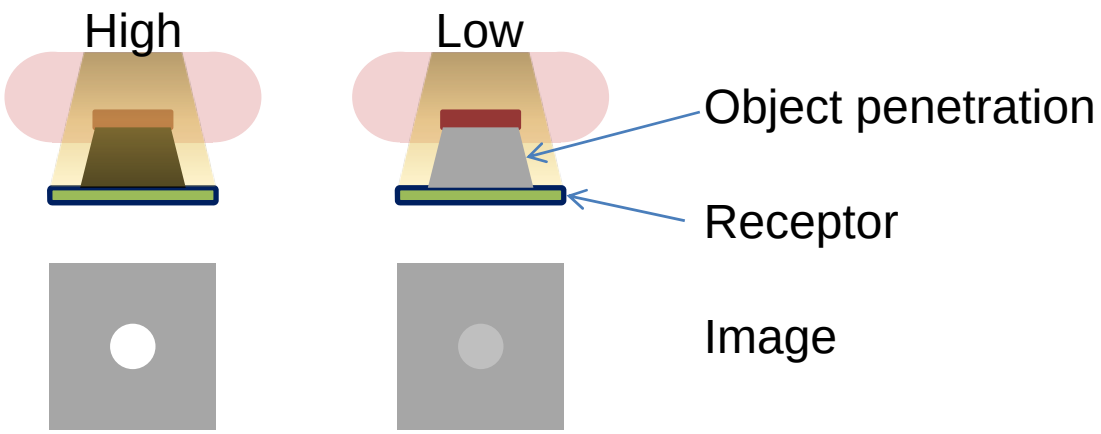
Radiography





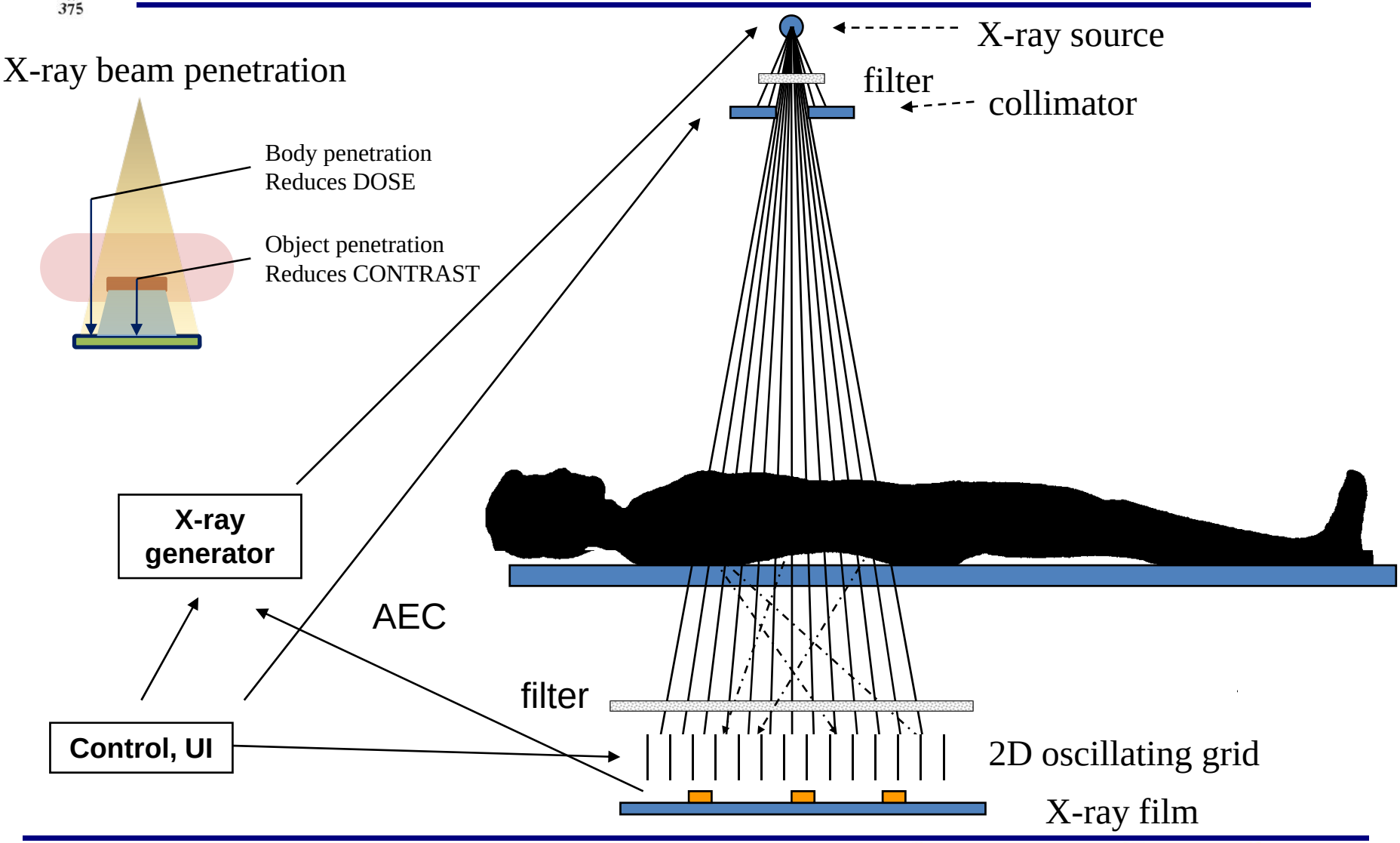


X-ray image contrast

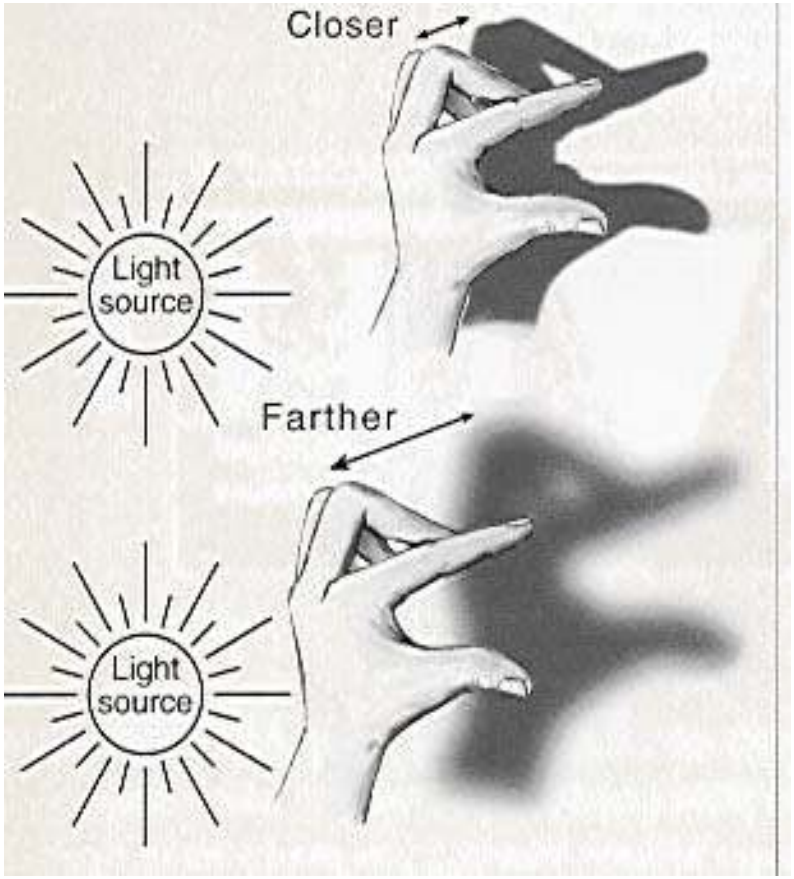


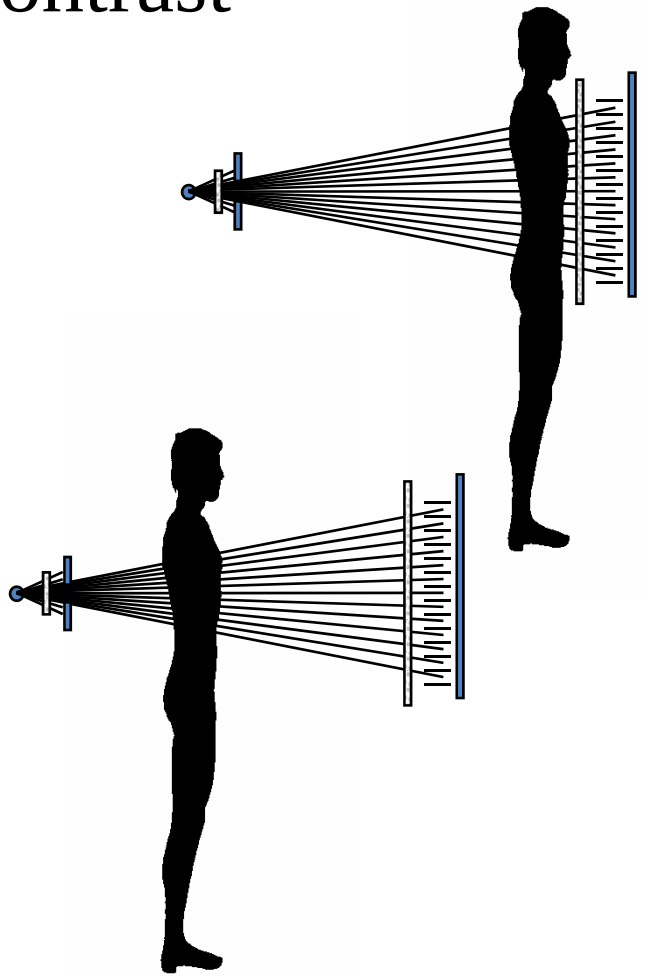
Material	Effective Atomic Number	Density (g/cm3)
Water	7.42	1.0
Muscle	7.46	1.0
Fat	5.92	0.91
Air	7.64	0.00129
Calcium	20.0	1.55
Iodine	53.0	4.94
Barium	56.0	3.5

Biomedical Imaging: Introduction and X-ray

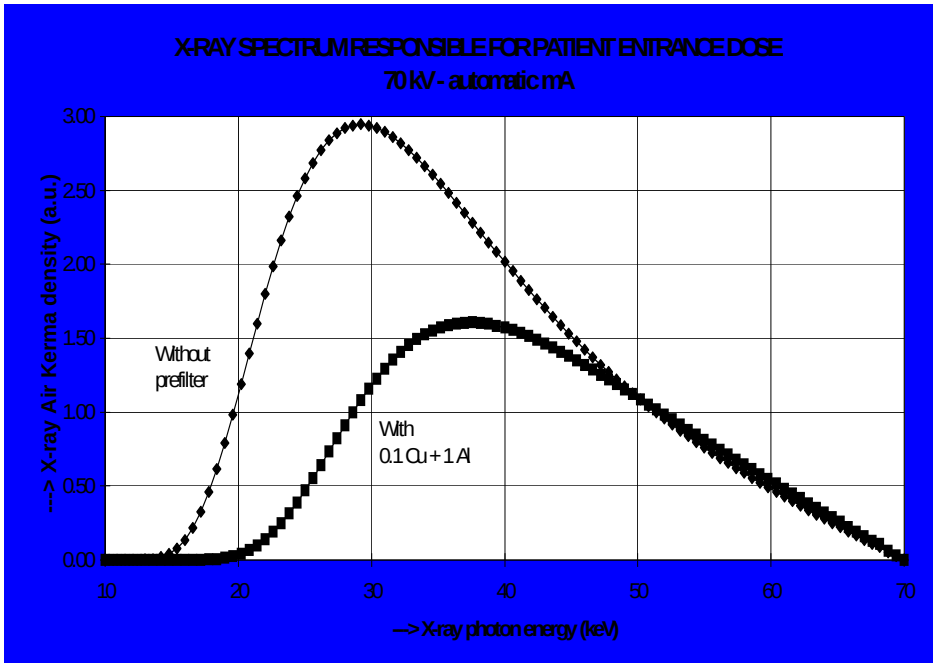


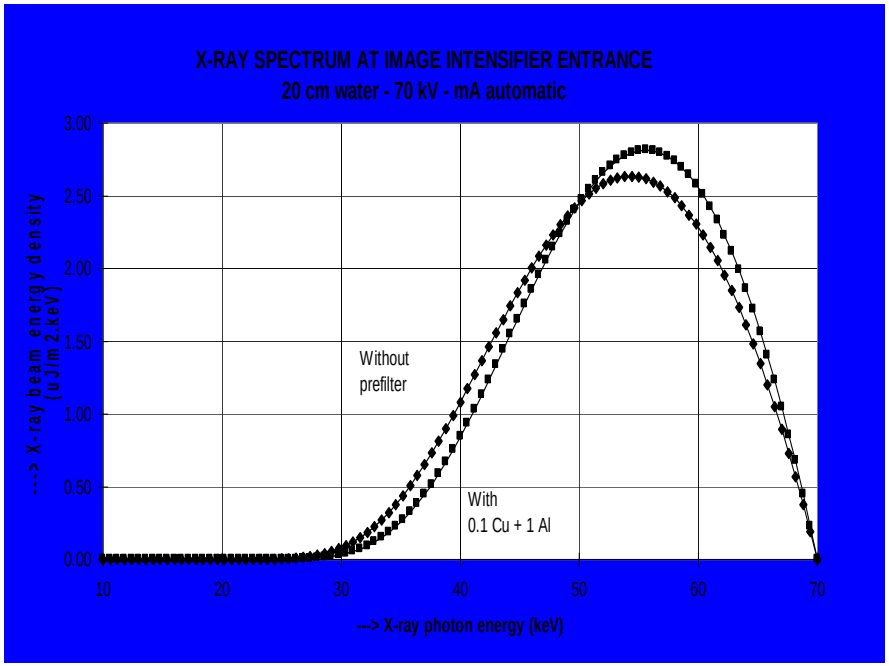
Magnification and edge-contrast





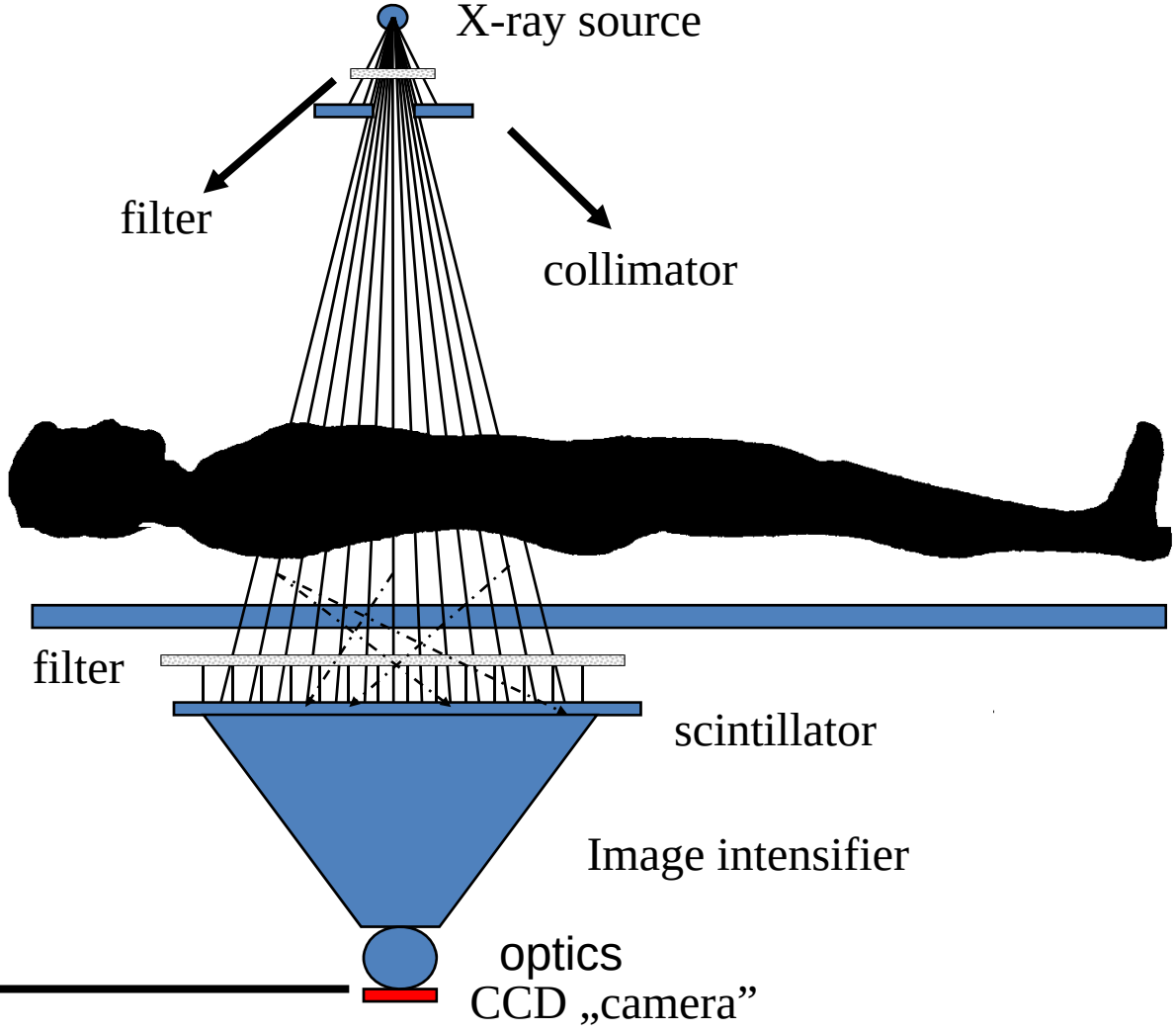
Filtering of x-ray





Typical multipurpose radiography equipment

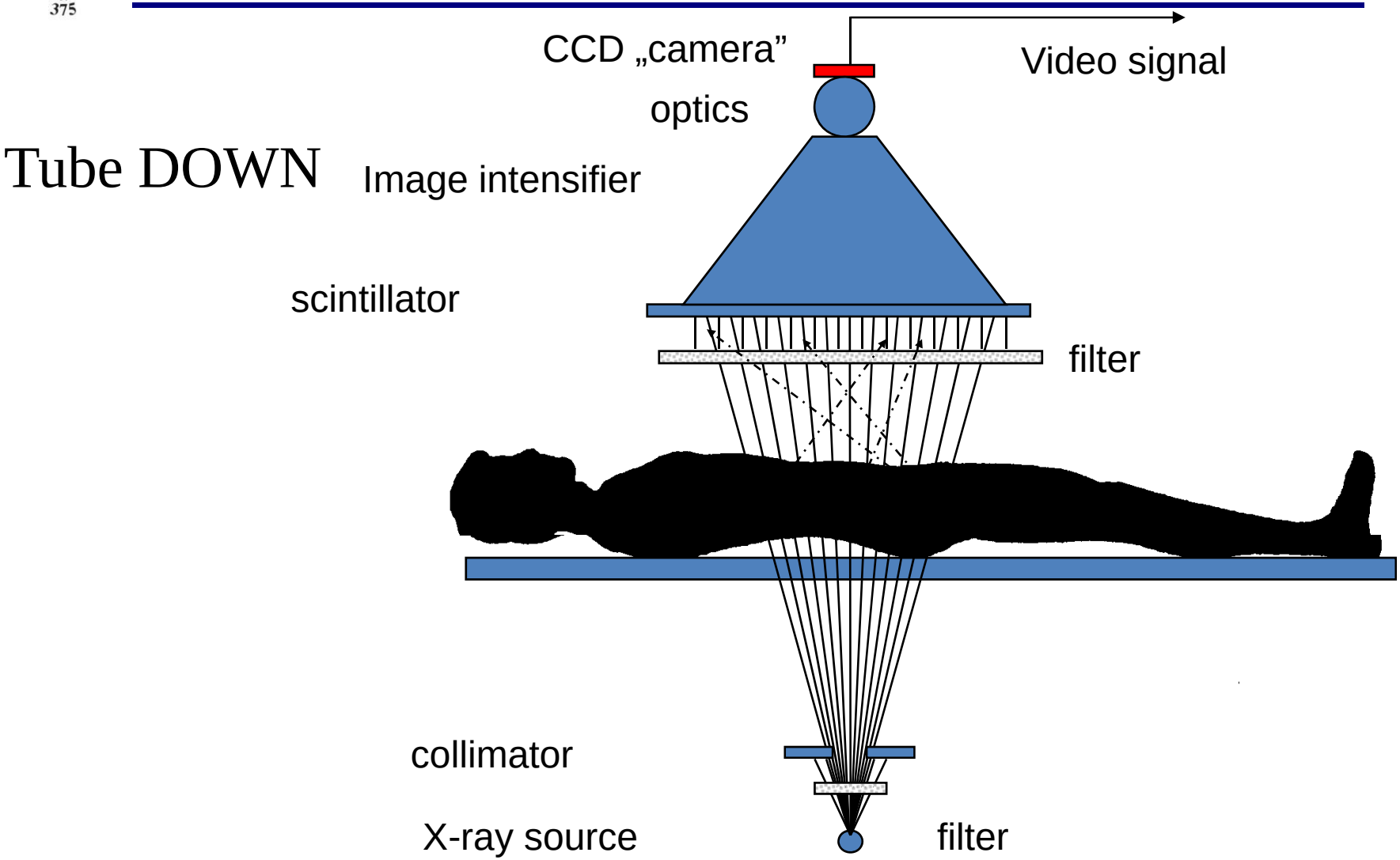
Fluoroscopy



Typical fluoroscopy equipment

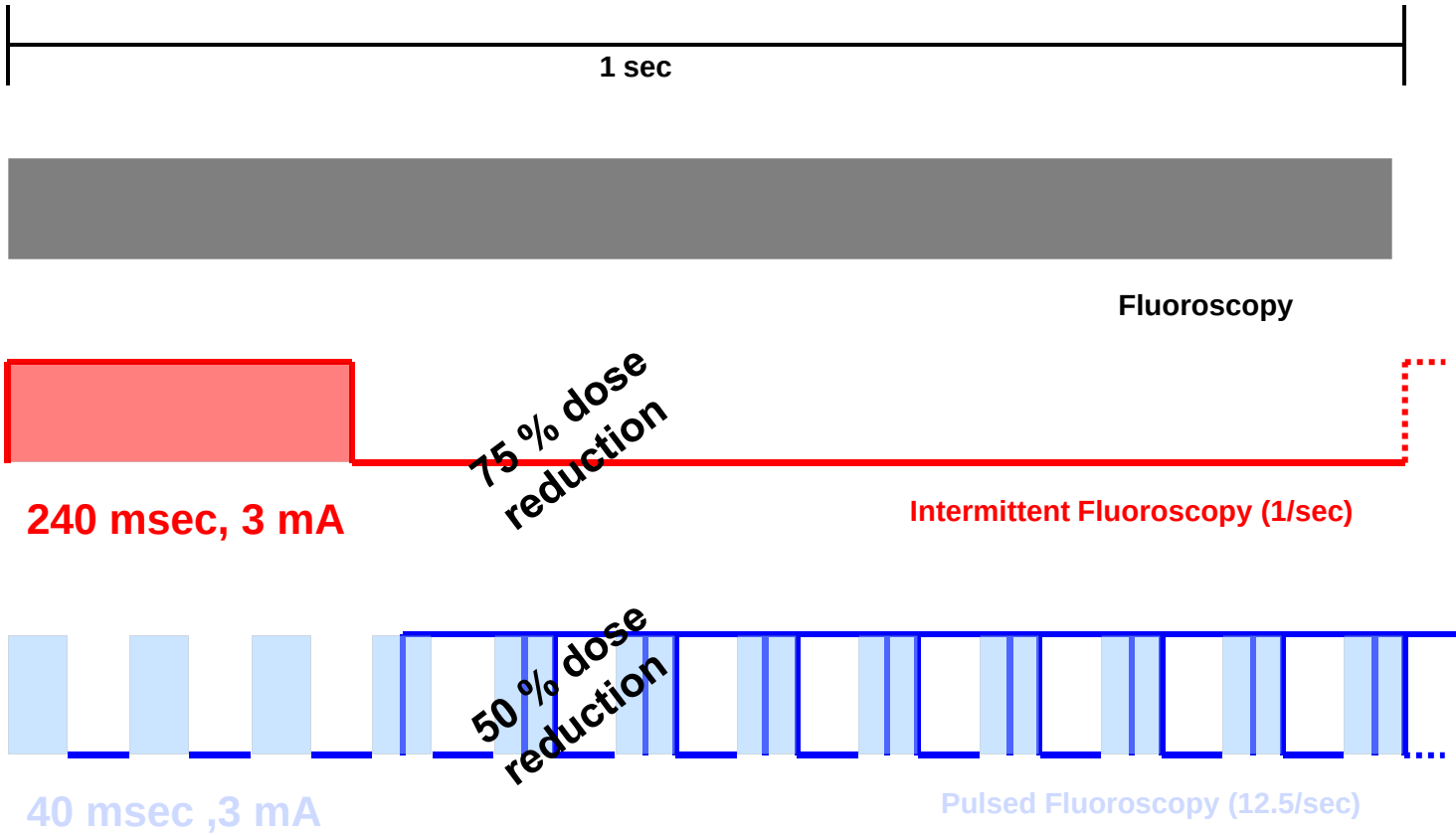
Tube in TOP position

Biomedical Imaging: Introduction and X-ray



Tube in BOTTOM position

A „dose reduction” technique

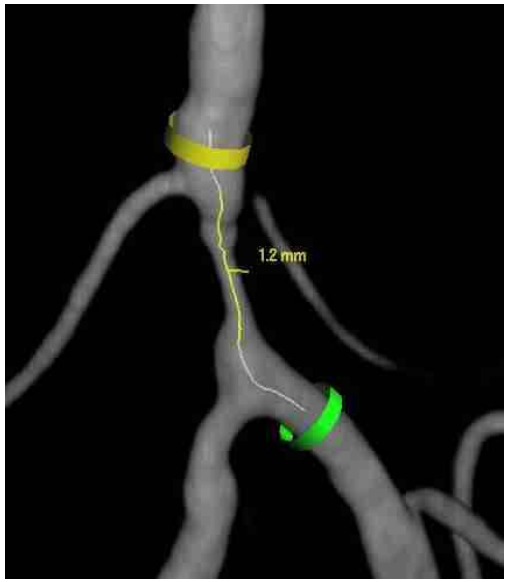


Surgery

Special mobile
fluoroscopy equipment

Digital Subtractive Angiography (DSA)

Rotational Angiography

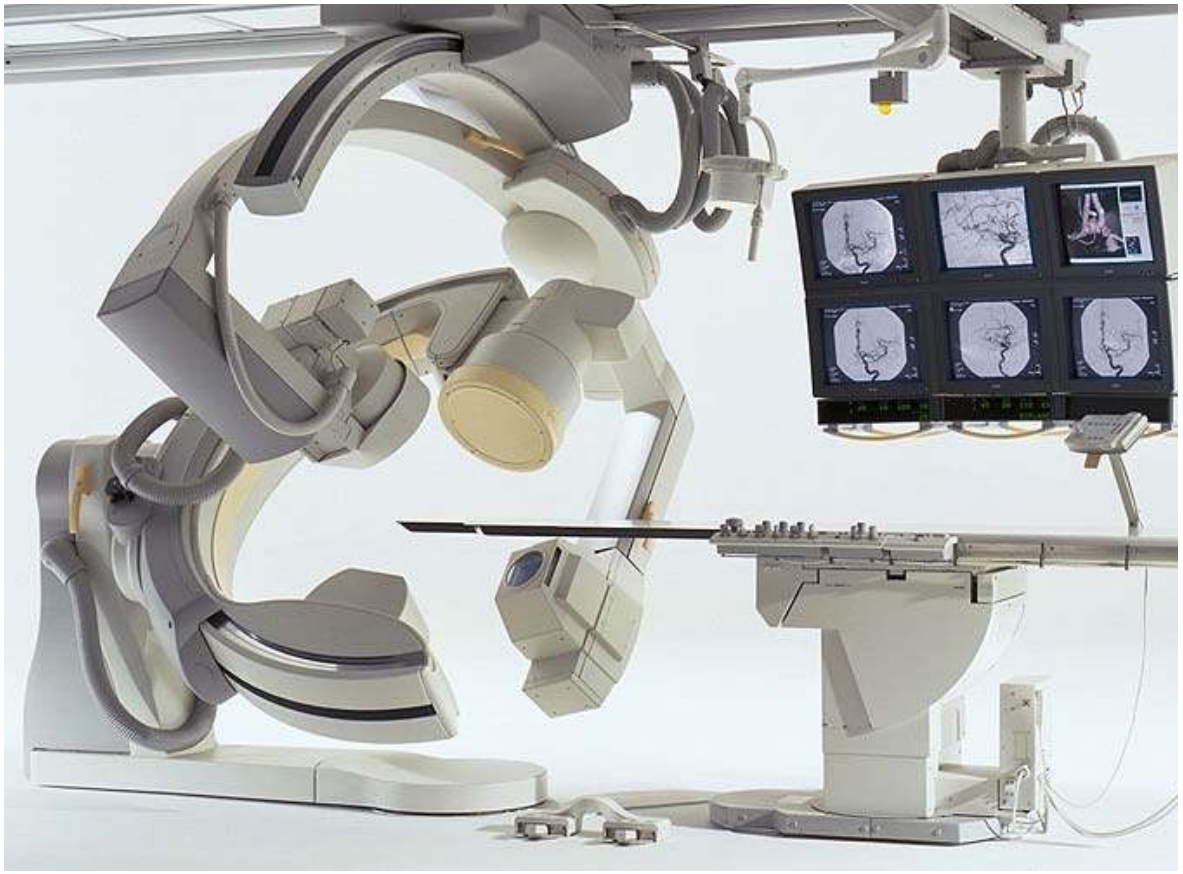


3 D imaging

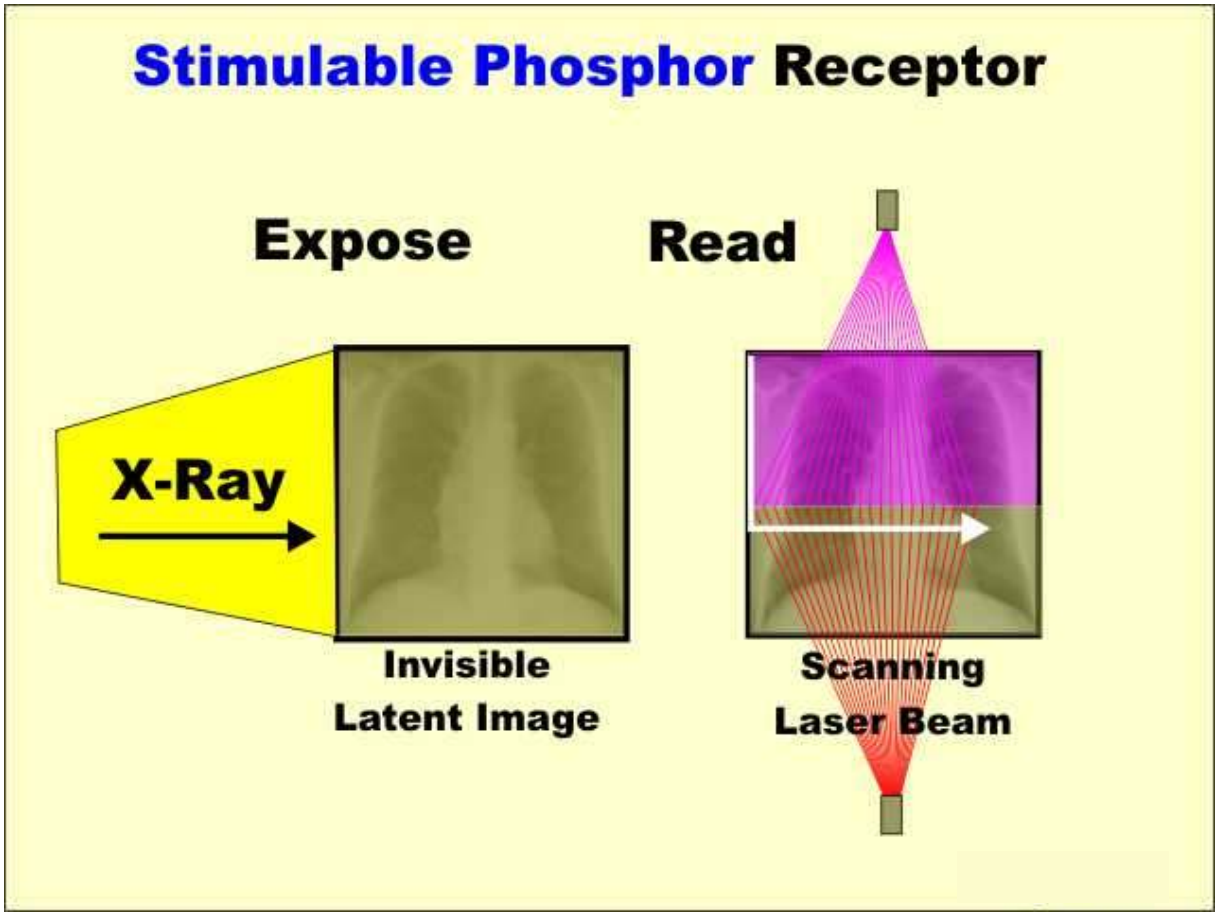
Simple measurement

High performance fluoroscopy equipment for angiography (Monoplane)

High performance fluoroscopy equipment for angiography (Bi-plane)

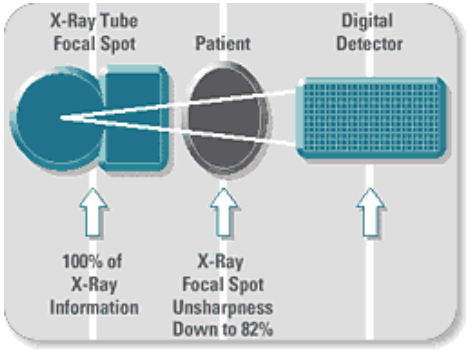


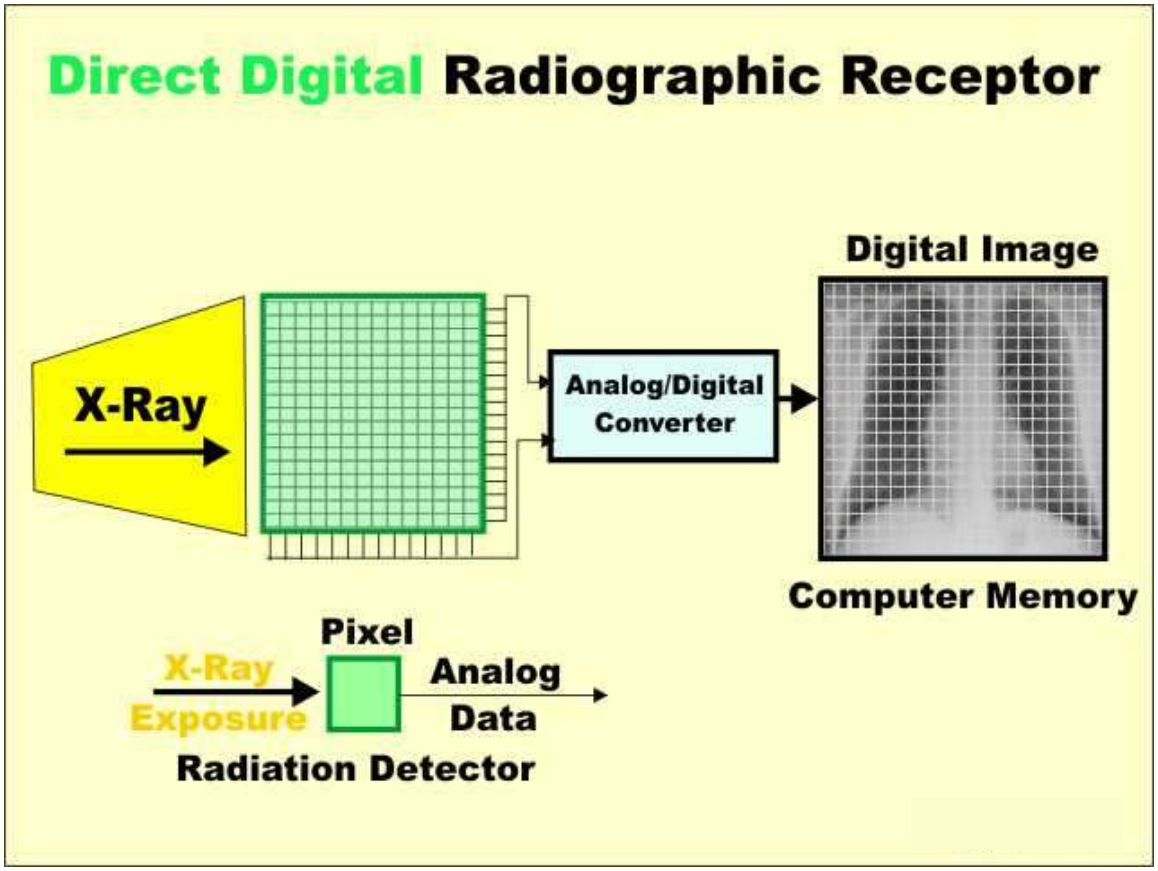
Computed Radiography



Typical phosphor-plate reader and cassettes

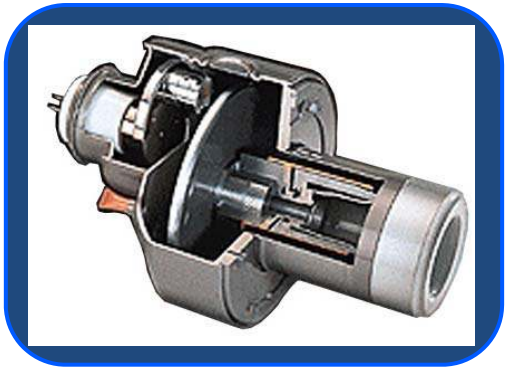
Direct Digital Radiography





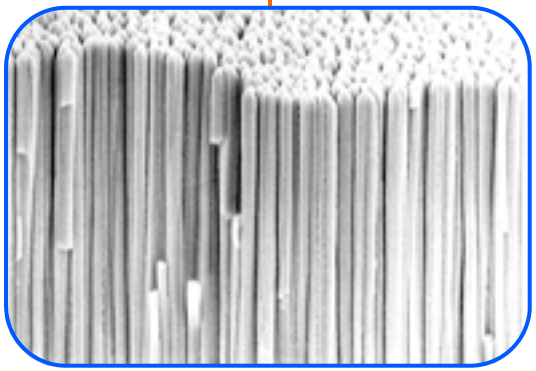
General purpose direct digital radiography system

Direct Digital DSA with Flat-detector

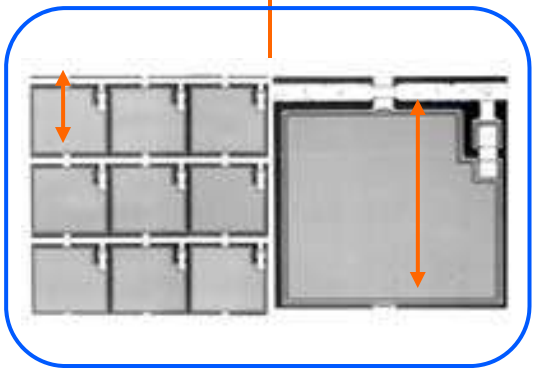


Flat detector

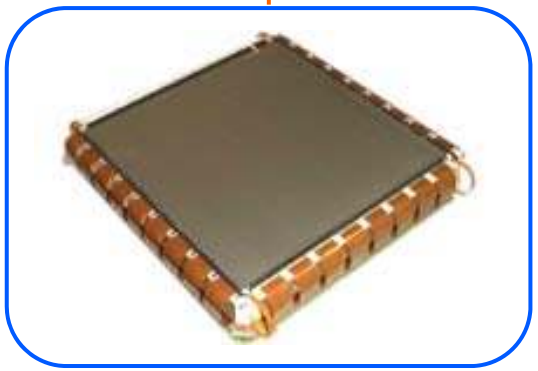
Direct digital x-ray detector for high performance and high speed fluoroscopy, angiography



Detection Layer

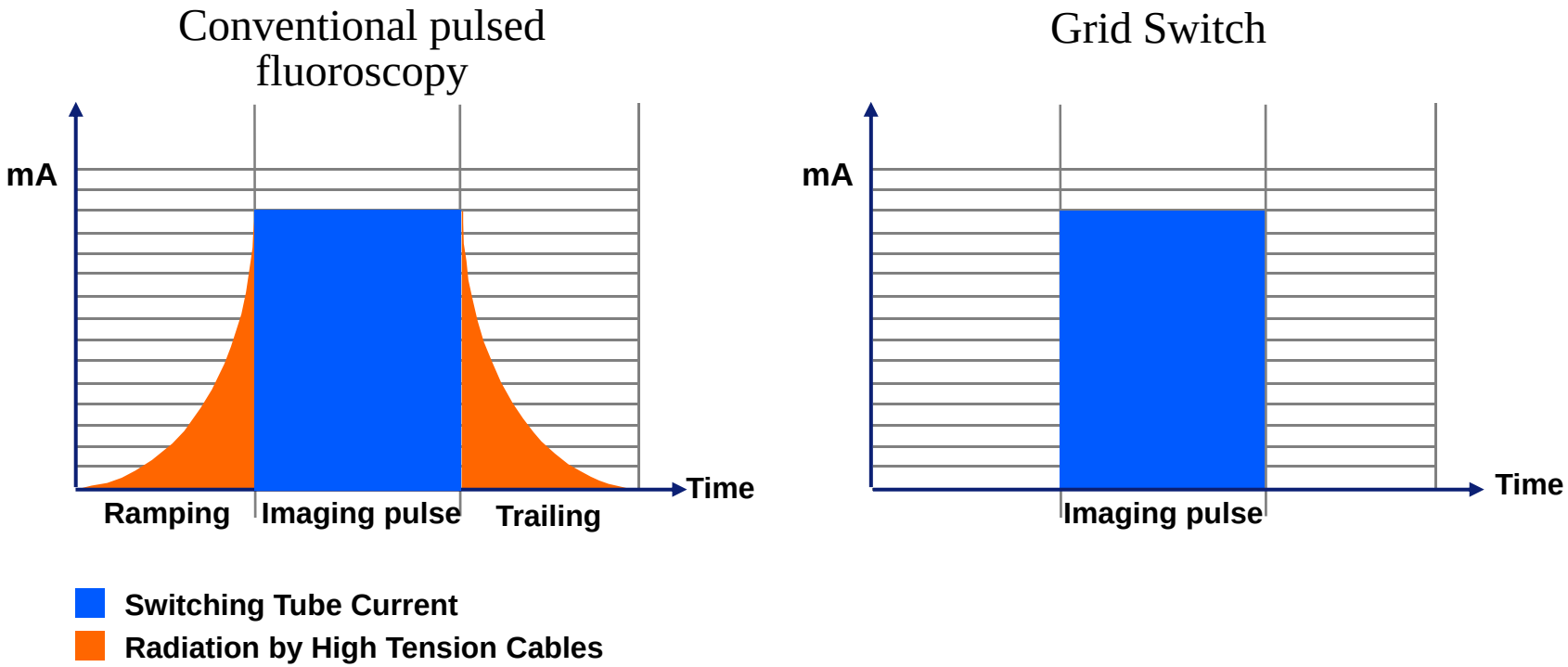


Photodiode Array



Refresh light

Grid Switch principle



SpectraBeam filtration

Filters out low-energy non-contributing X-rays, reducing patient dose:

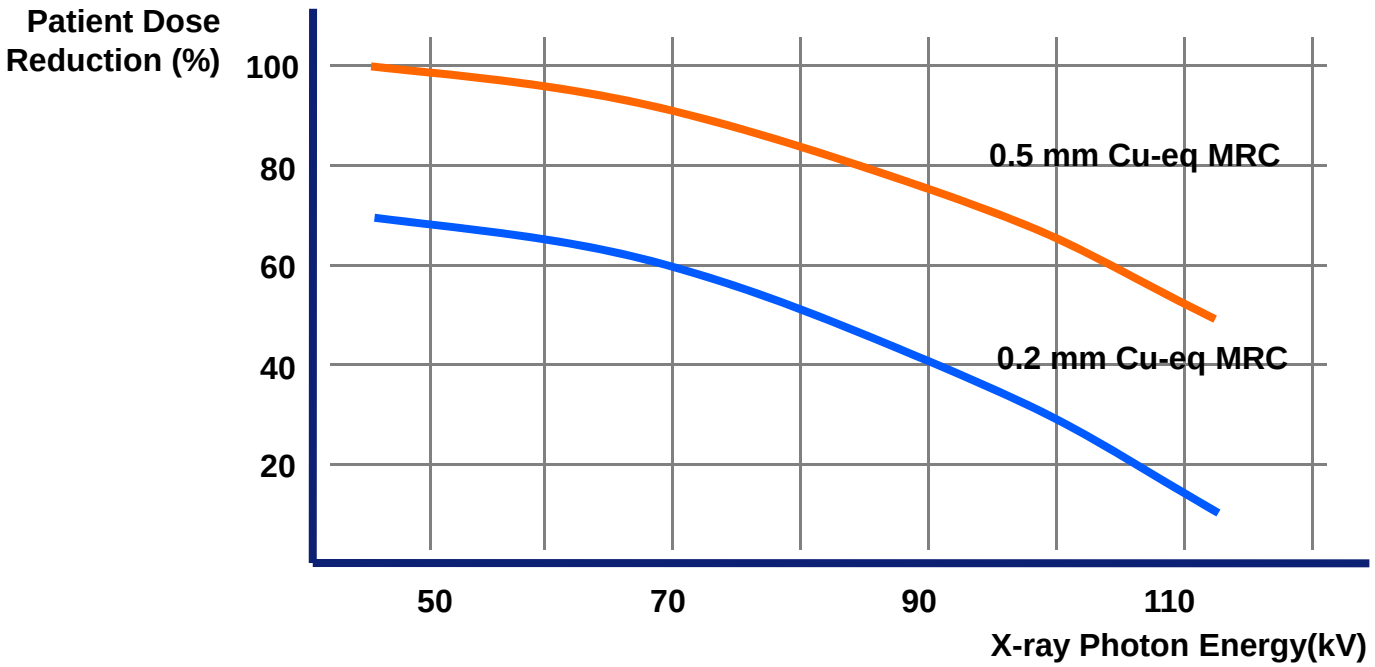


Image quality and dose management

Conventional X-ray tube
MRC X-ray tube – 0.2mm Cu
MRC X-ray tube – 0.5mm Cu

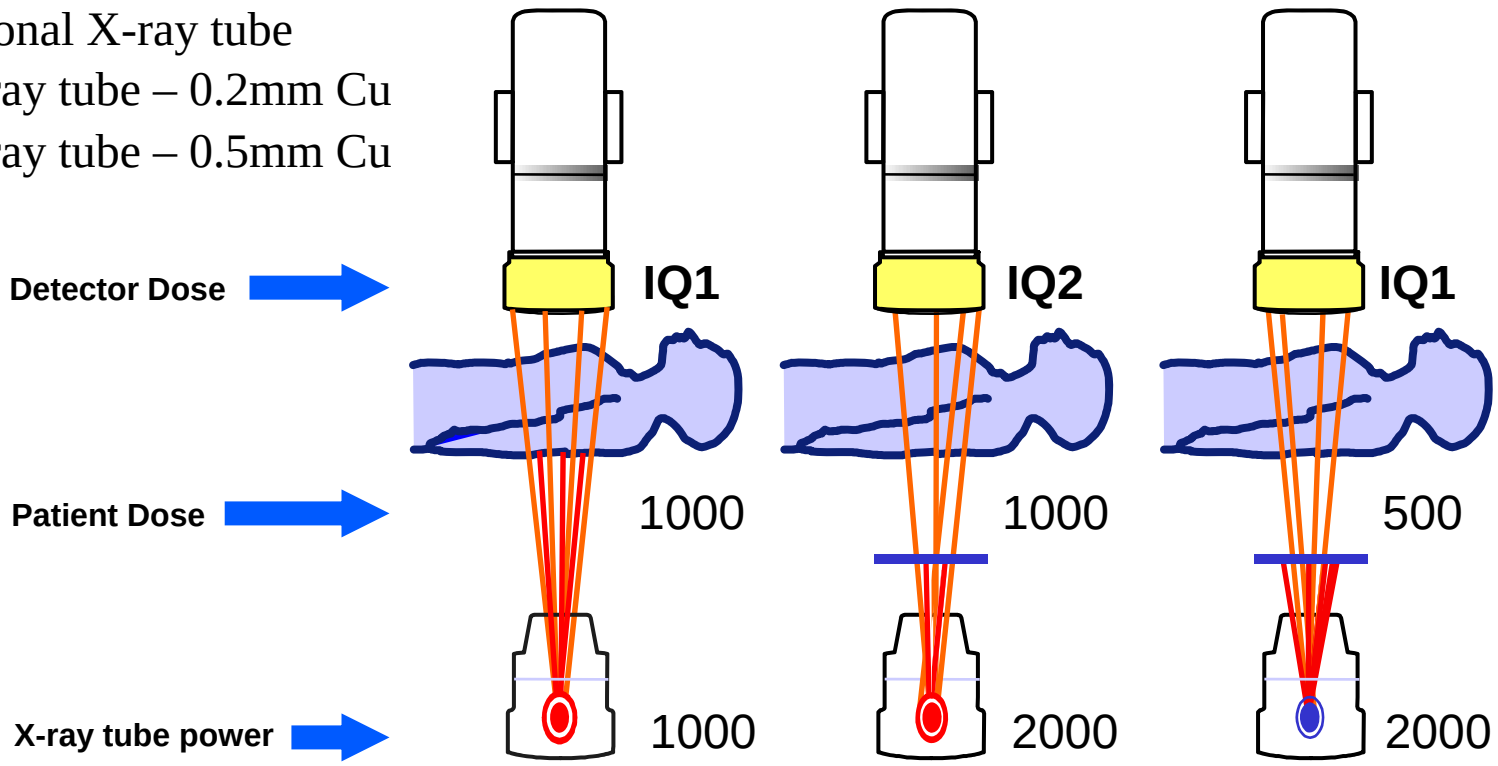


Image quality and dose management