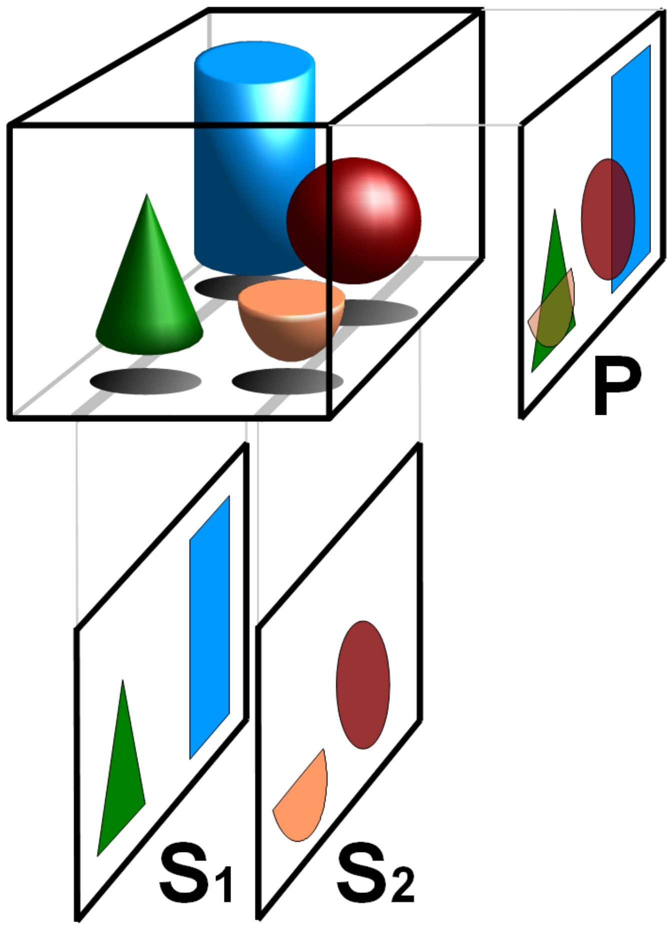
Computed Tomography
CT

F. Grüner; many slides from Dr. C. Hoeschen and C. Braun from HMGU; Cheong et al., Phys Med Biol 55, 647

Vor der CT: Radiographie → Problem der Superposition

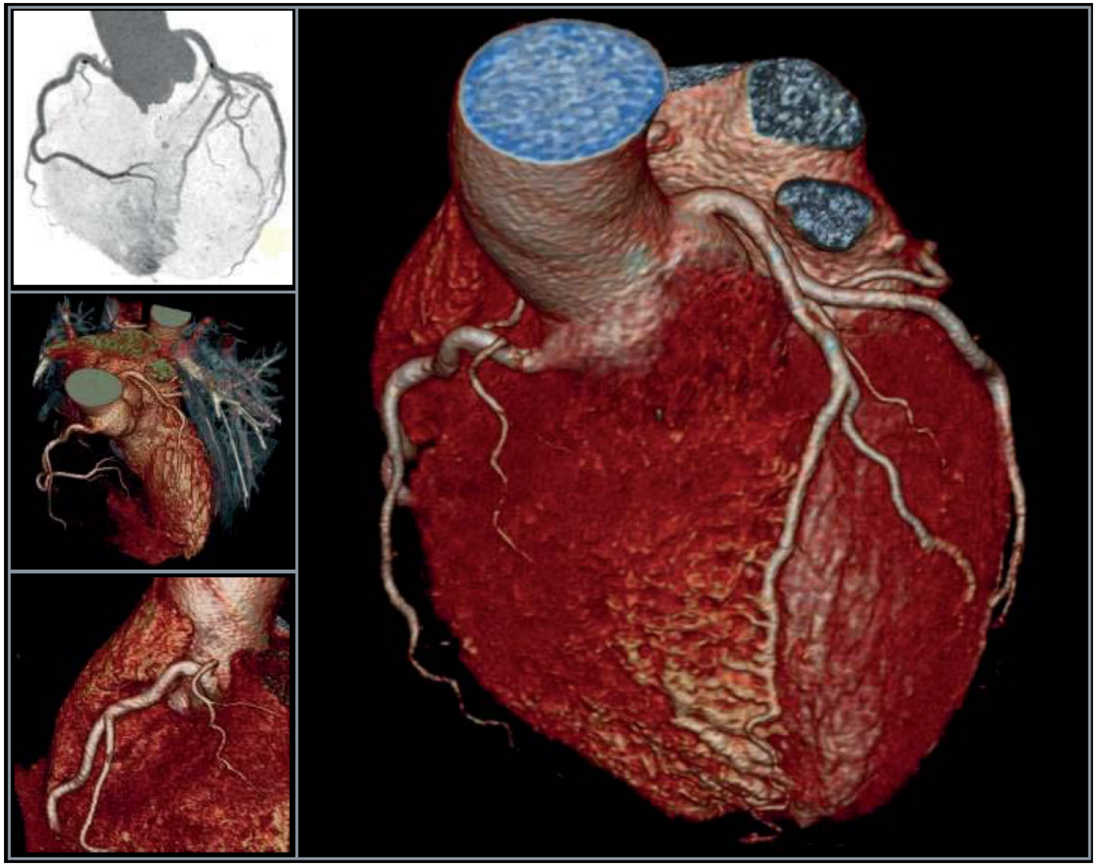


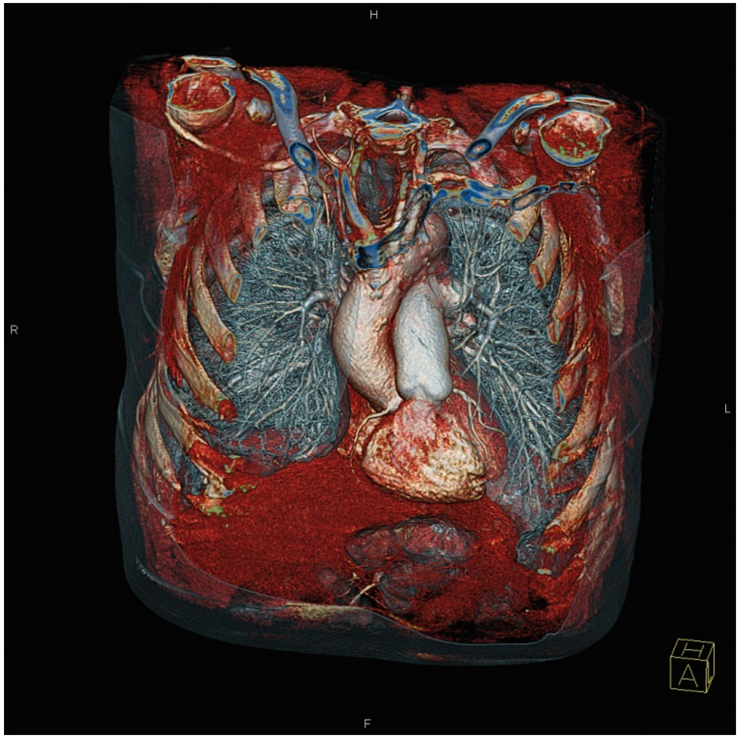
Gewöhnliche Radiographie

↔ CT Schicht

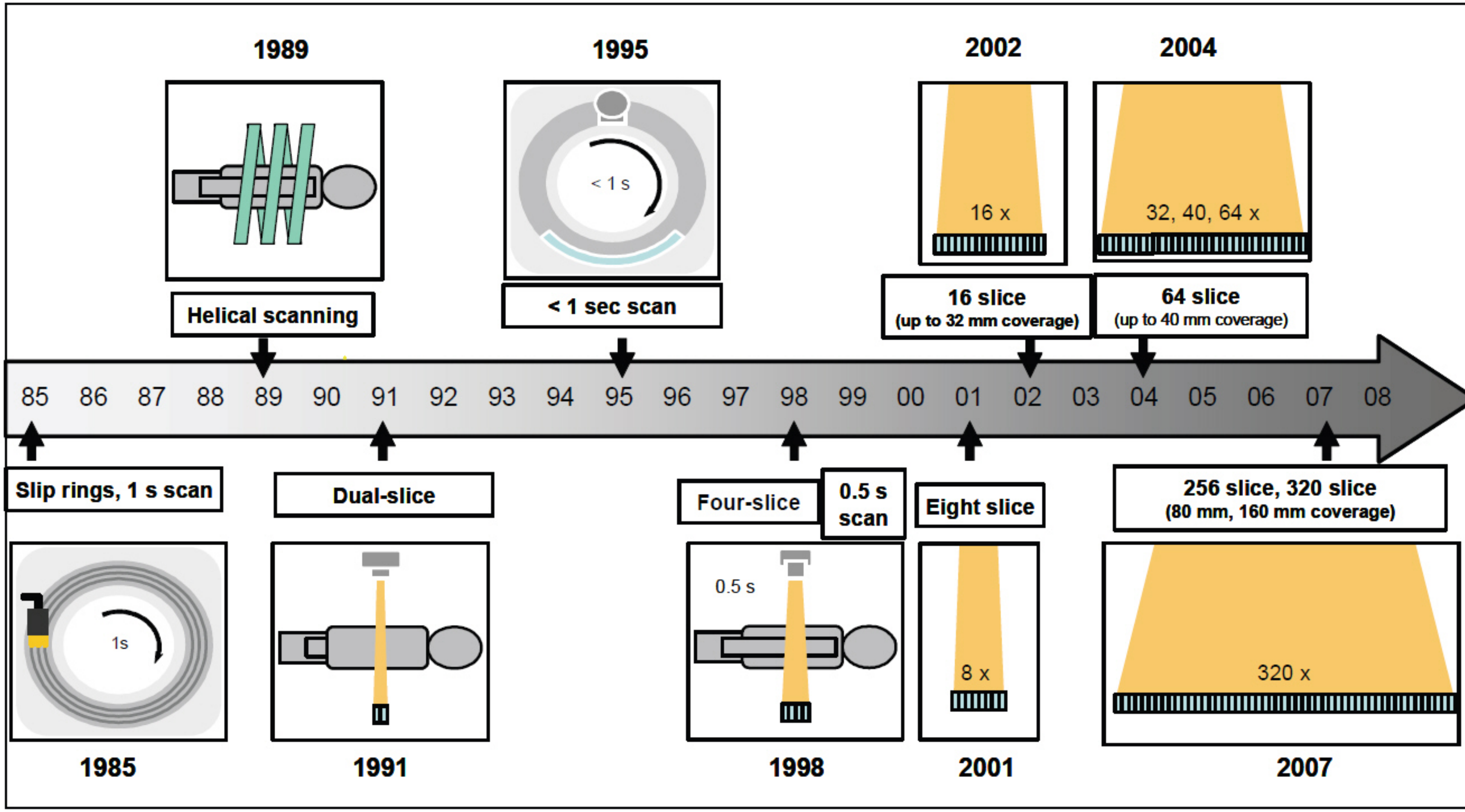
Von: Wikipedia und O. Effenberger

CT examples

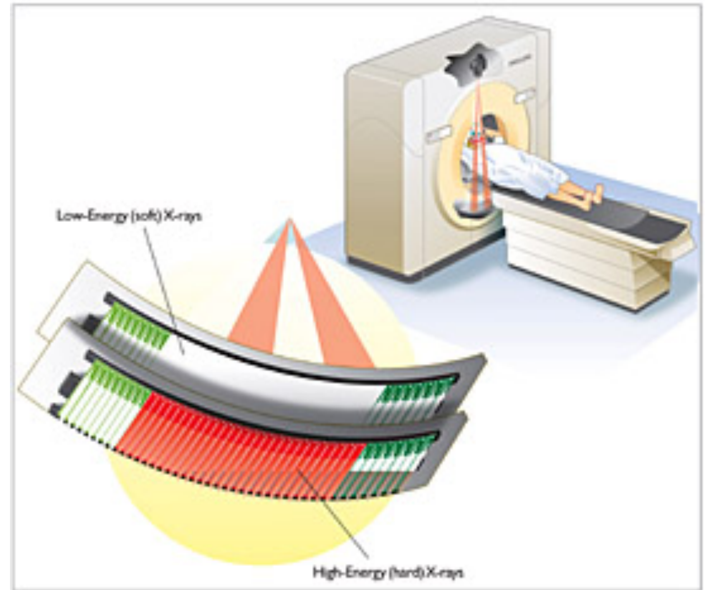




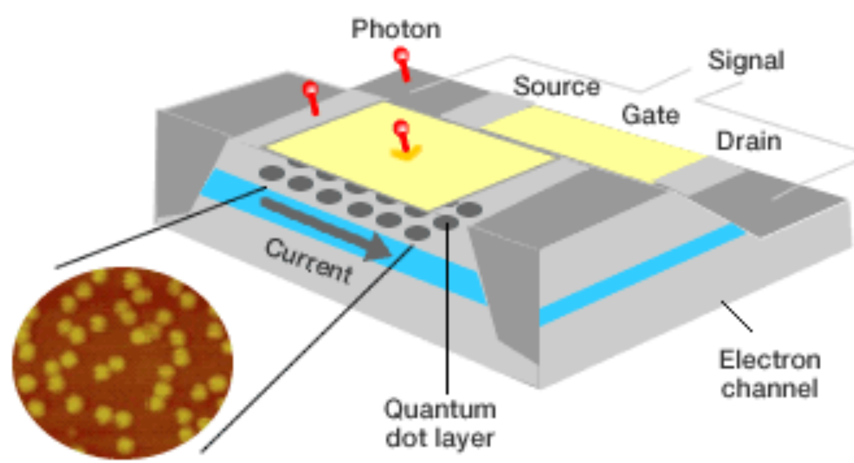
CT Gerätetechnologie 1985 bis 2008



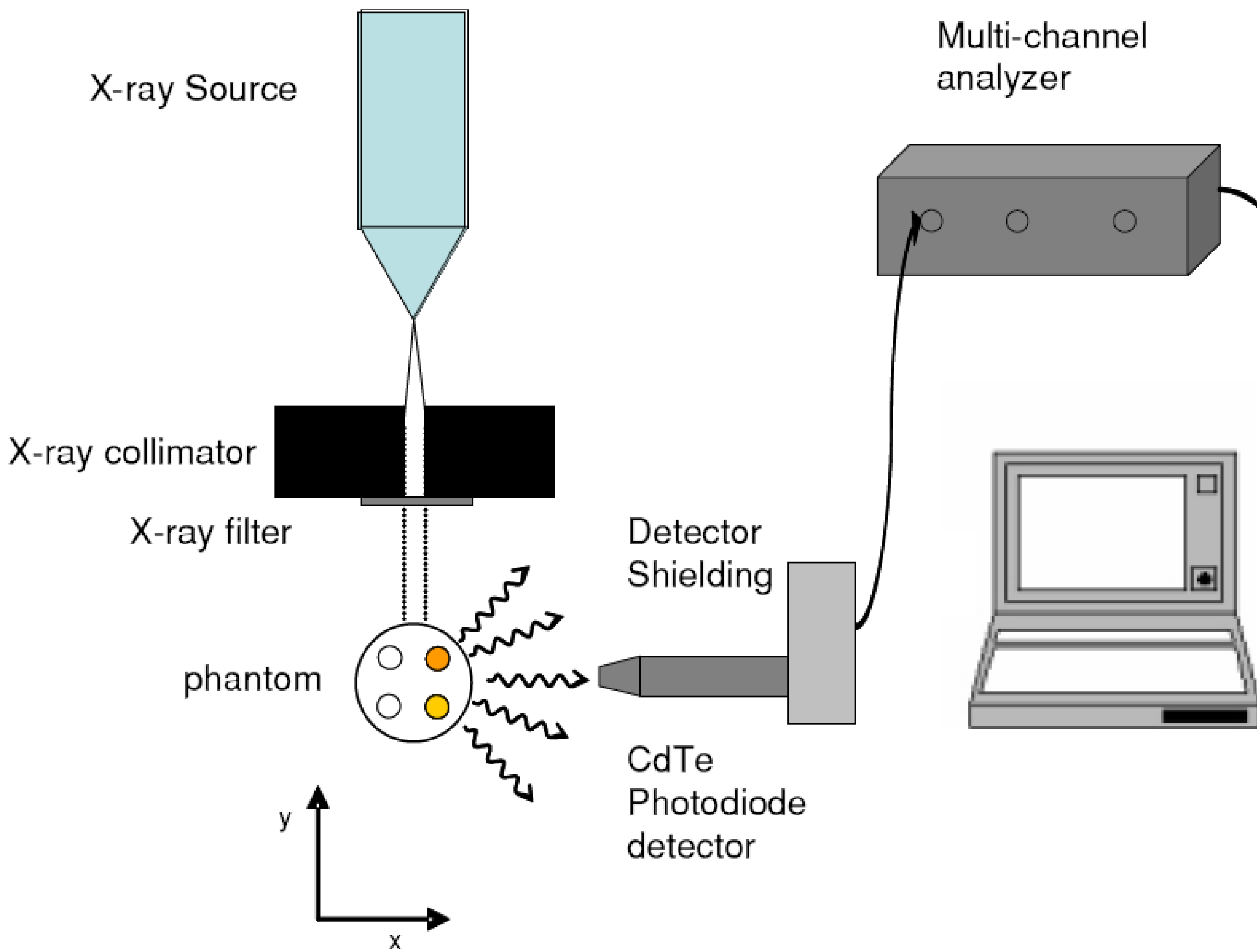
Faster – Further – Finer



CT heute und seine Detektoren



Example: again X-ray fluorescence technique



Basics

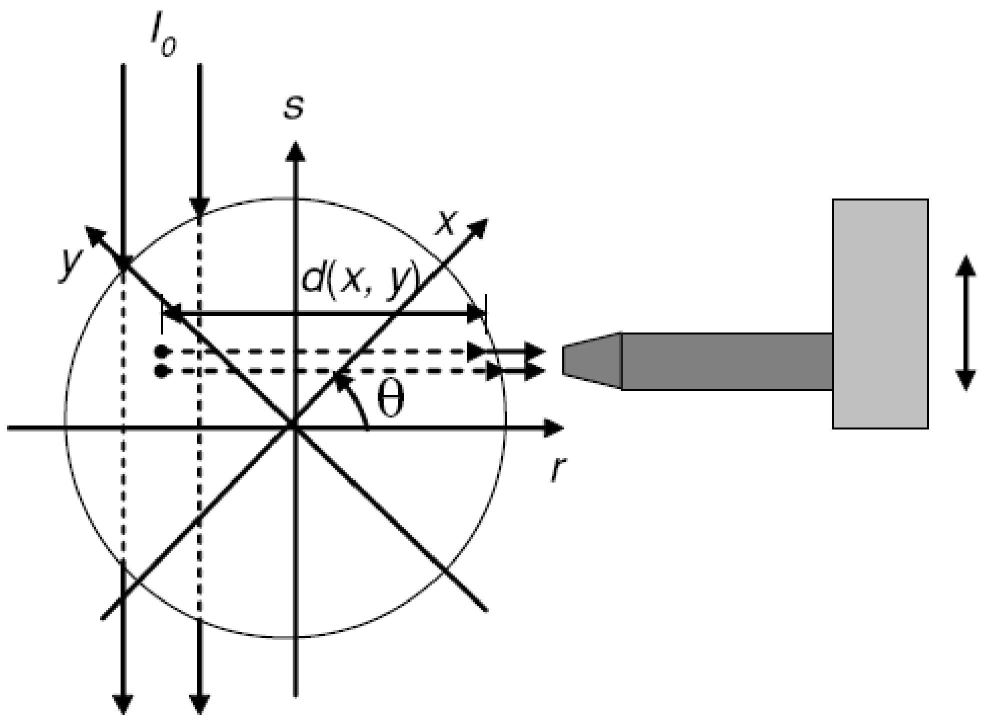


Figure 4. Definition of phantom (x, y) and laboratory (r, s) coordinate systems.

Sinogram

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} r \\ s \end{bmatrix}$$

$\rho(x, y)$ represents the Au concentration

F is measured fluorescence yield

$$F(r,\theta) = \alpha I_0 \left[\int_s \rho(x, y)\, \mathrm{d}s \right] = \alpha I_0 \left[\int_s \rho\, (r\cos\theta + s\sin\theta, -r\sin\theta + s\cos\theta)\, \mathrm{d}s \right]$$

↑

Radon transform (R)

the sinogram $p(r, \theta)$ in polar coordinates (r, θ) is defined by

$$p(r, \theta) = R[\rho(x, y)] = \frac{F(r, \theta)}{\alpha I_0}$$

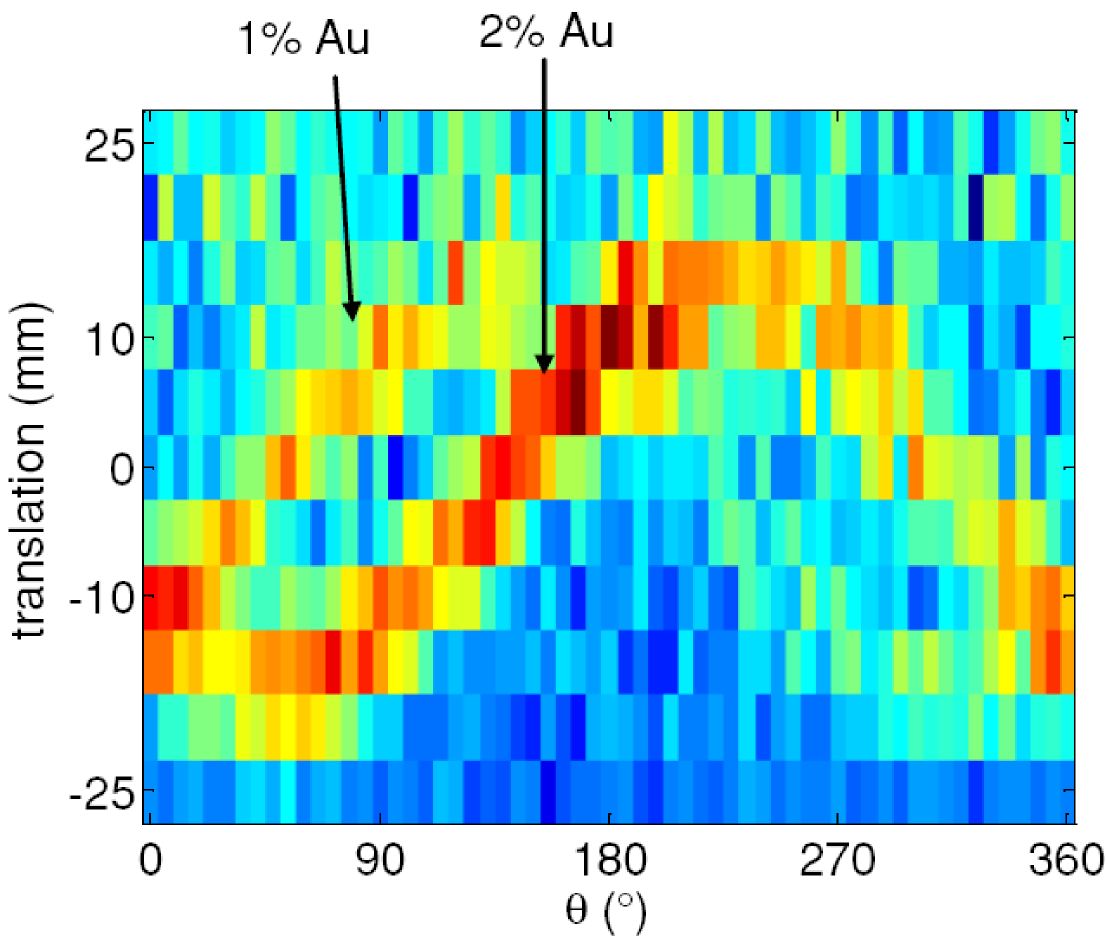
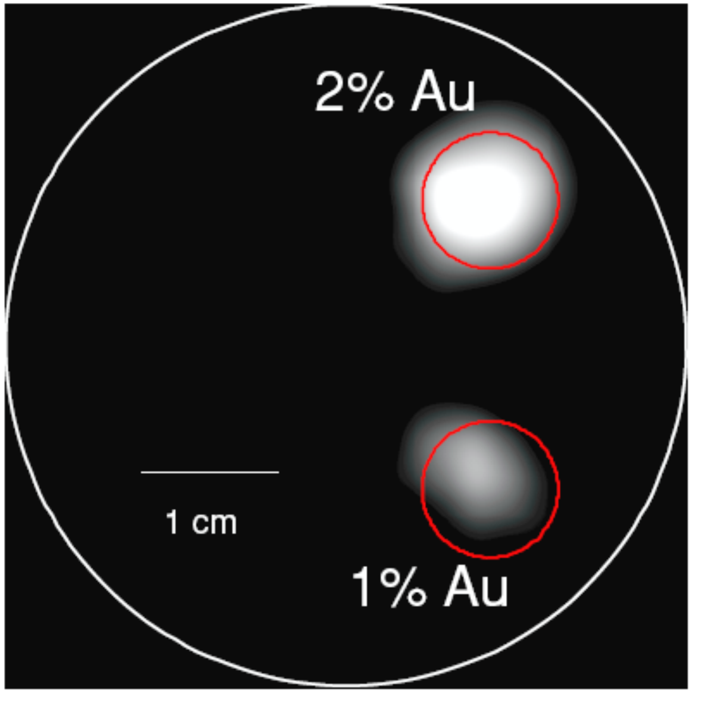


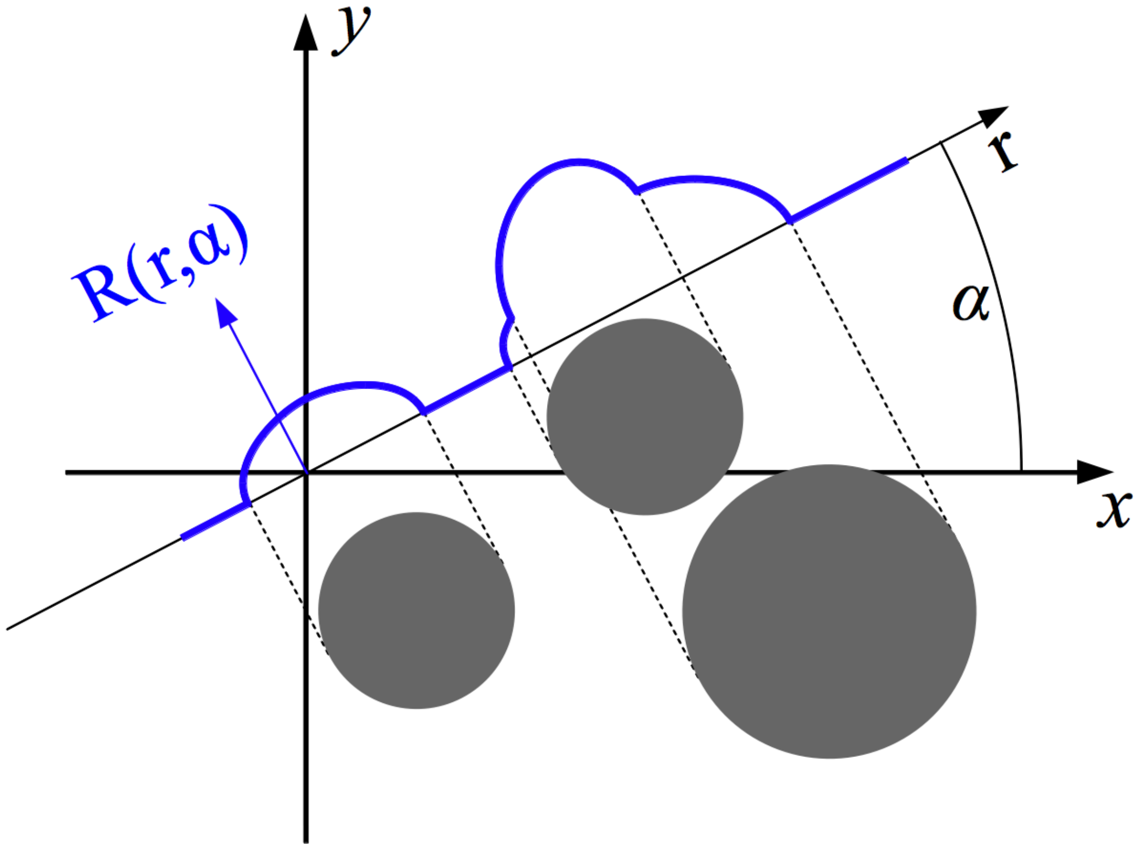
Image reconstruction

reconstructed image $\hat{\rho}(x, y)$

$$\hat{\rho}(x, y) = R^{-1}[p(r, \theta)] = \int_0^{2\pi} p(r, \theta)\, \mathrm{d}\theta$$



Radon transformation

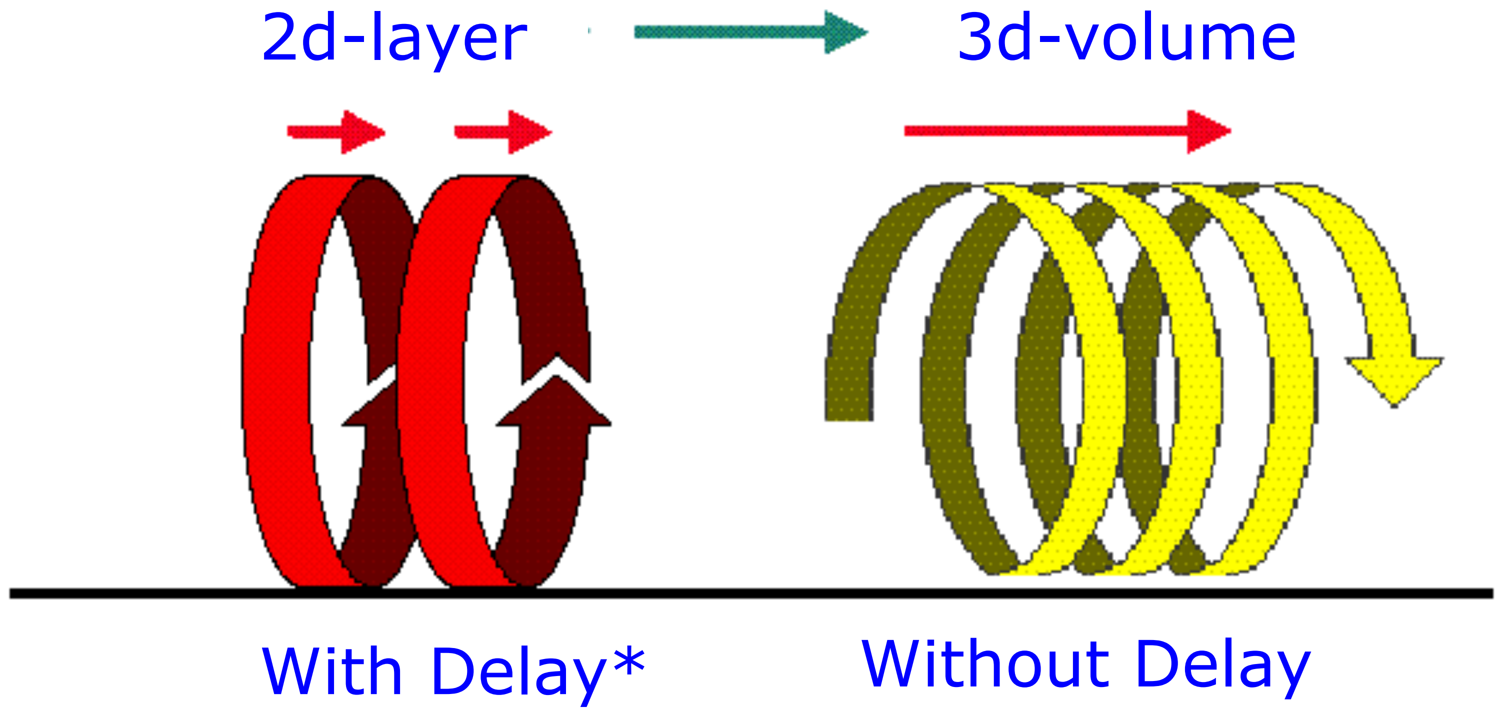


Function in grey area == 1, else == 0

Radon inverse either by filter back-projection or via Fourier transform

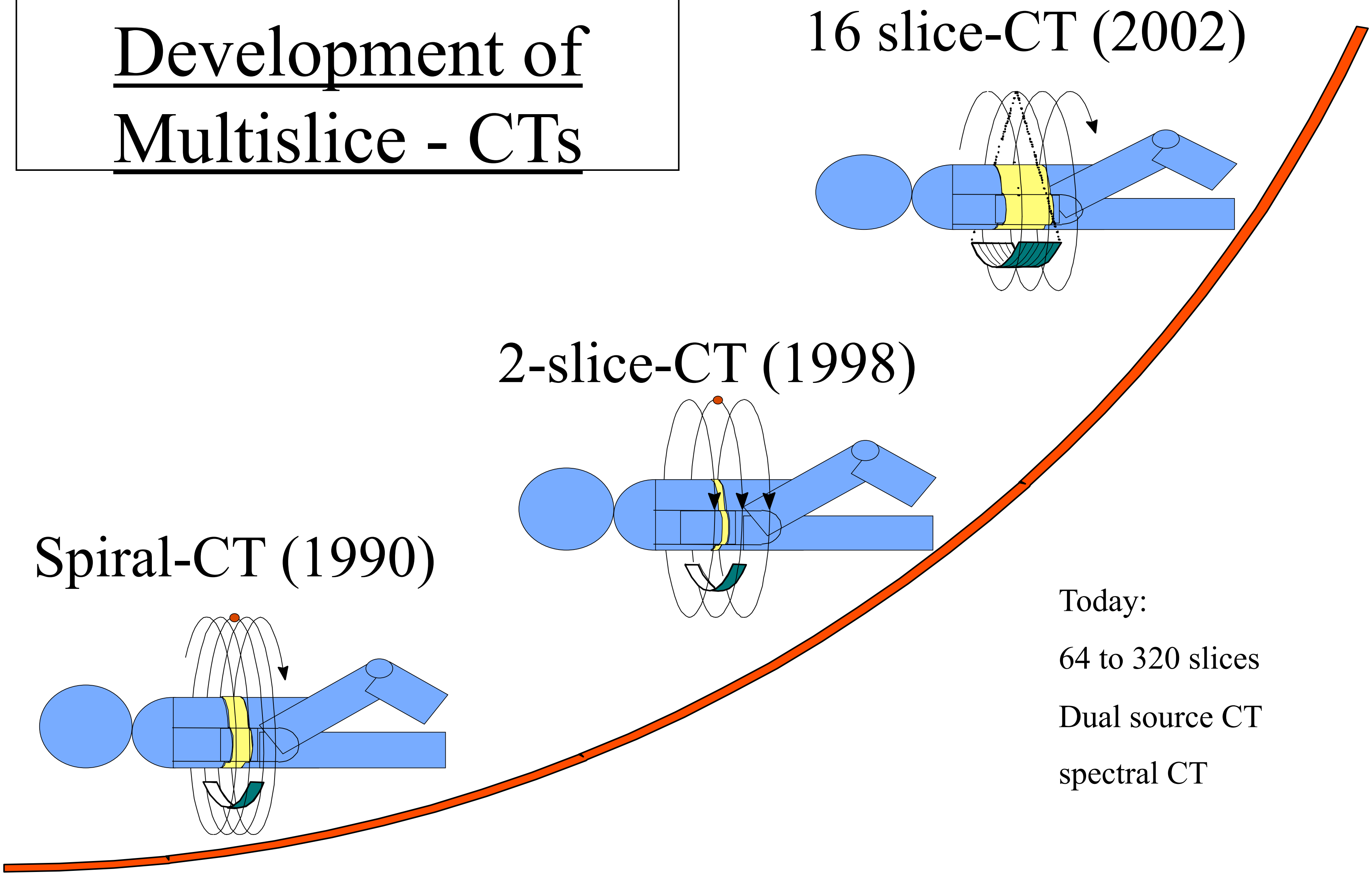
Axial Scanning → Helical Scanning

Conventional CT ←→ Spiral-CT



* Delay between slicescans

Development of Multislice - CTs



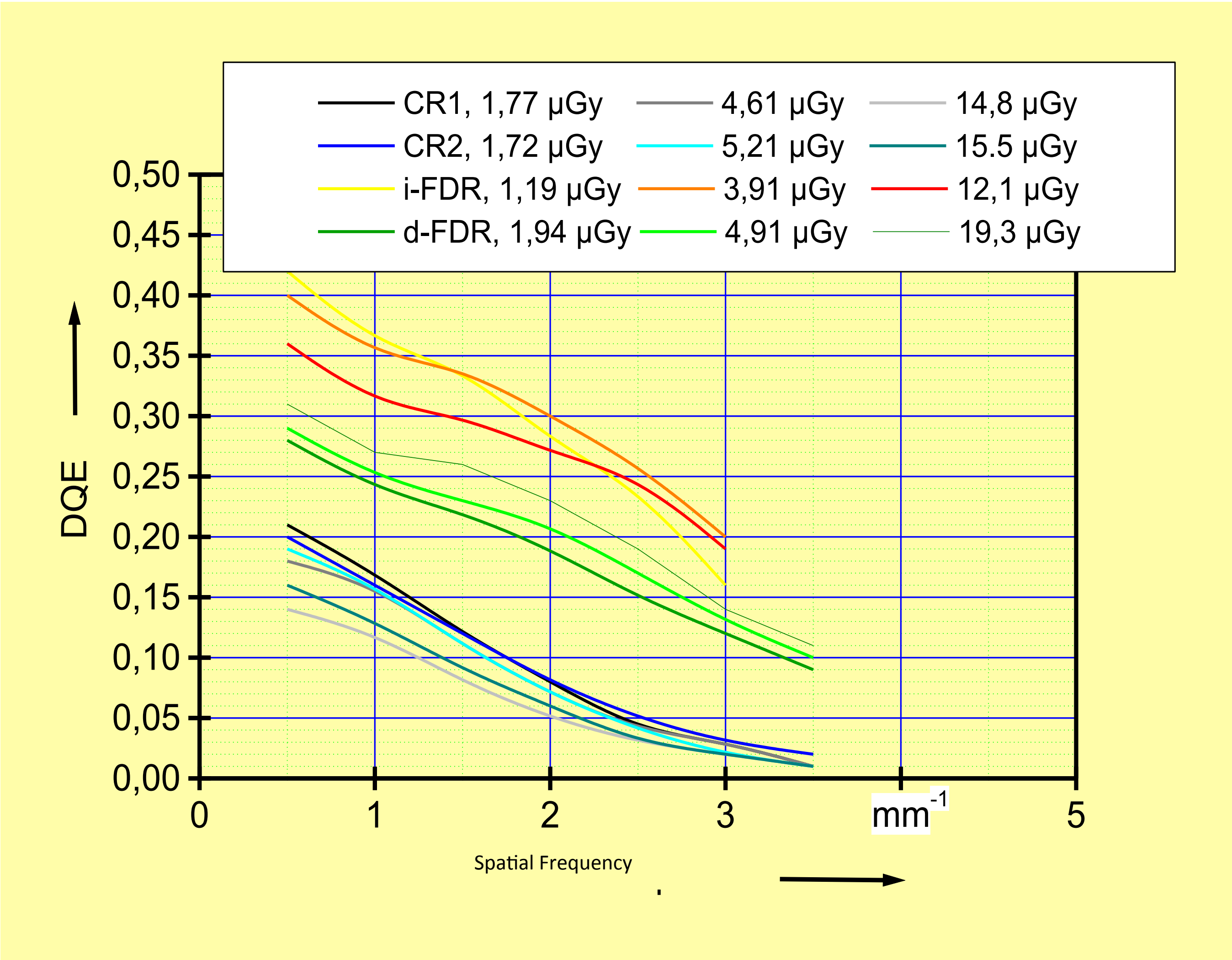
Today:

64 to 320 slices

Dual source CT

spectral CT

dose: detective quantum efficiency radiation dose efficiency



A method for describing the doses delivered by transmission x-ray computed tomography[a)]

Thomas B. Shope, Robert M. Gagne, and Gordon C. Johnson

Bureau of Radiological Health, Food and Drug Administration, 5600 Fishers Lane, Rockville, Maryland 20857

(Received 23 September 1980; accepted for publication 3 October 1980)

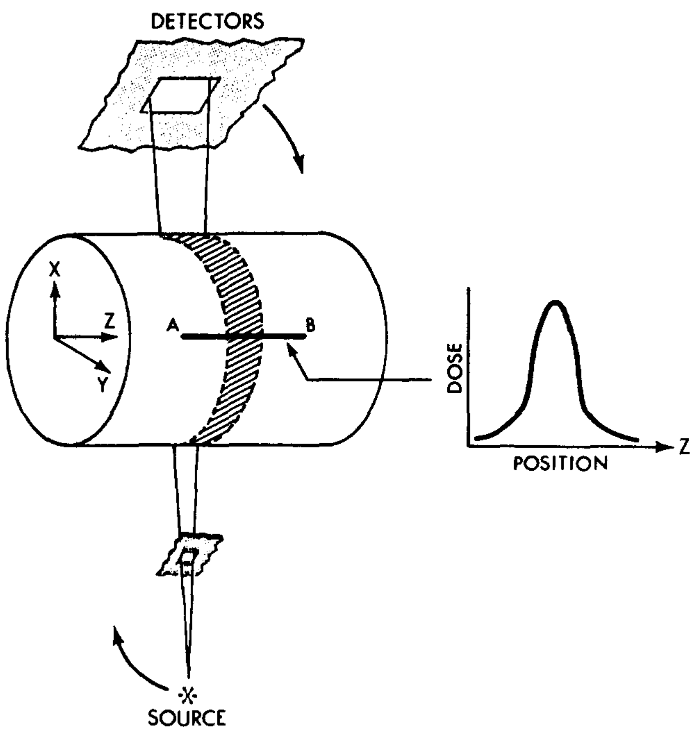


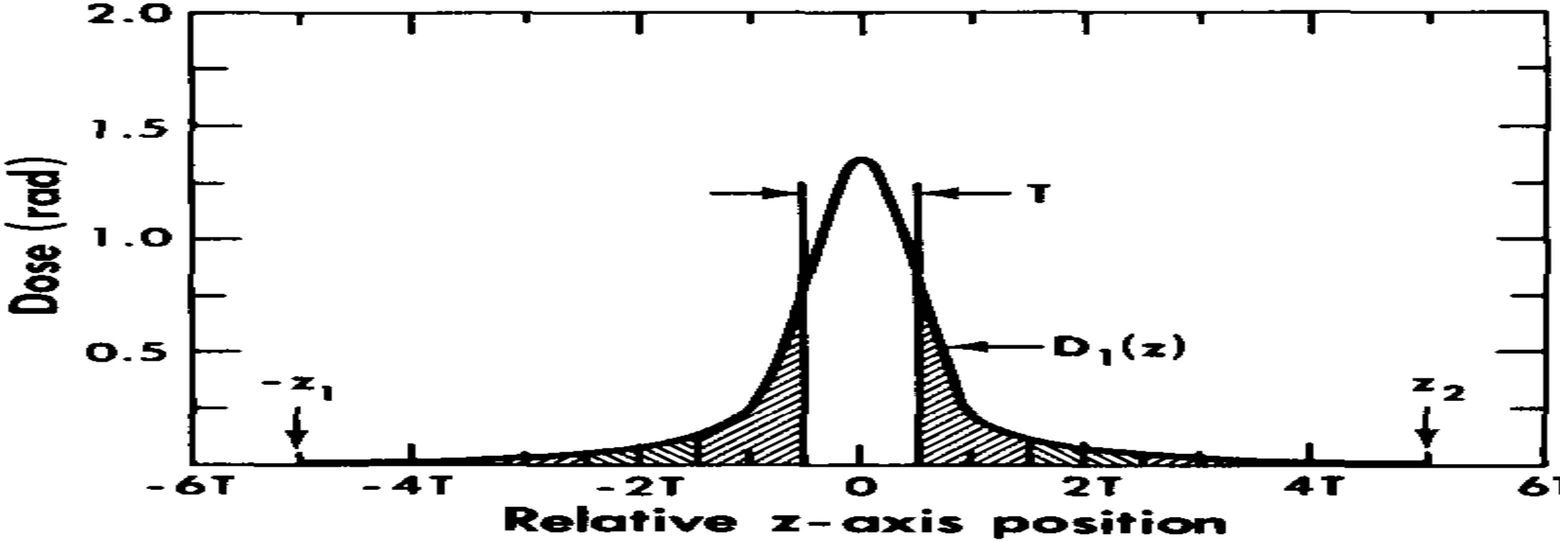
FIG. 1. Illustration of CT system geometry, coordinate system used, and typical dose distribution resulting from a single scan of CT system.

II. SUGGESTED DOSE DESCRIPTOR FOR COMPUTED TOMOGRAPHY

The dose descriptor we propose is the computed tomography dose index (CTDI) denoted as C and defined by

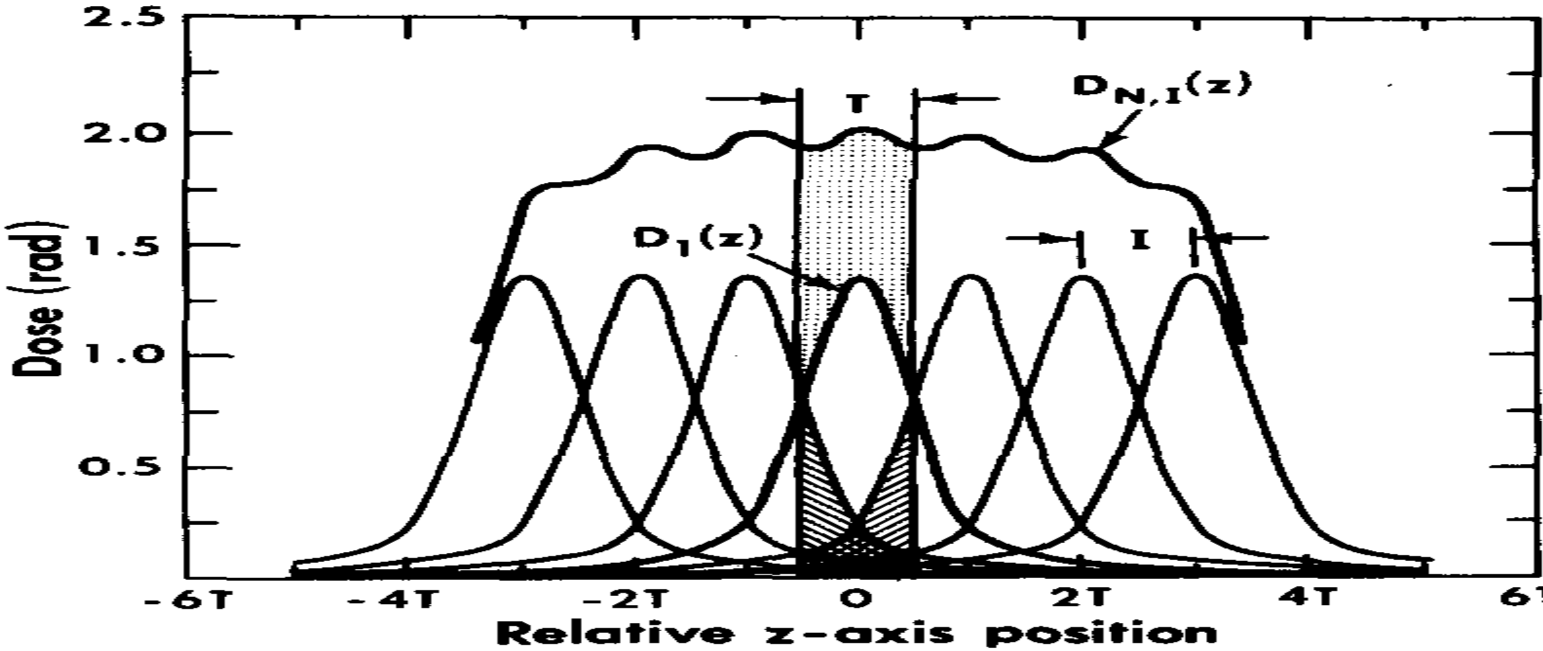
$$C = (1/T) \int_{-\infty}^{\infty} D_1(z)dz, \qquad (1)$$

where $D_1(z)$ is the dose as a function of position along the z axis coordinate for a single scan dose profile at a given point (x,y). T is the slice thickness as stated by the manufacturer or selected by the CT system operator. The CTDI will be shown below to be equal to the average dose along the z direction at the point (x,y) over the central scan of a series of scans when the series consists of a large number of scans separated by the slice thickness.



2.0
1.5
1.0
0.5
Dose (rad)
T
$D_1(z)$
$-z_1$
z_2
-6T
-4T
-2T
0
2T
4T
6T
Relative z-axis position

(a)



2.5
2.0
1.5
1.0
0.5
Dose (rad)
T
$D_{N,I}(z)$
$D_1(z)$
I
-6T
-4T
-2T
0
2T
4T
6T
Relative z-axis position

dose

mamma screening: 3 mGy (absorbed in organ), 0.4 mSv (in whole body)

Chest: 13 mGy, 5-7 mSv

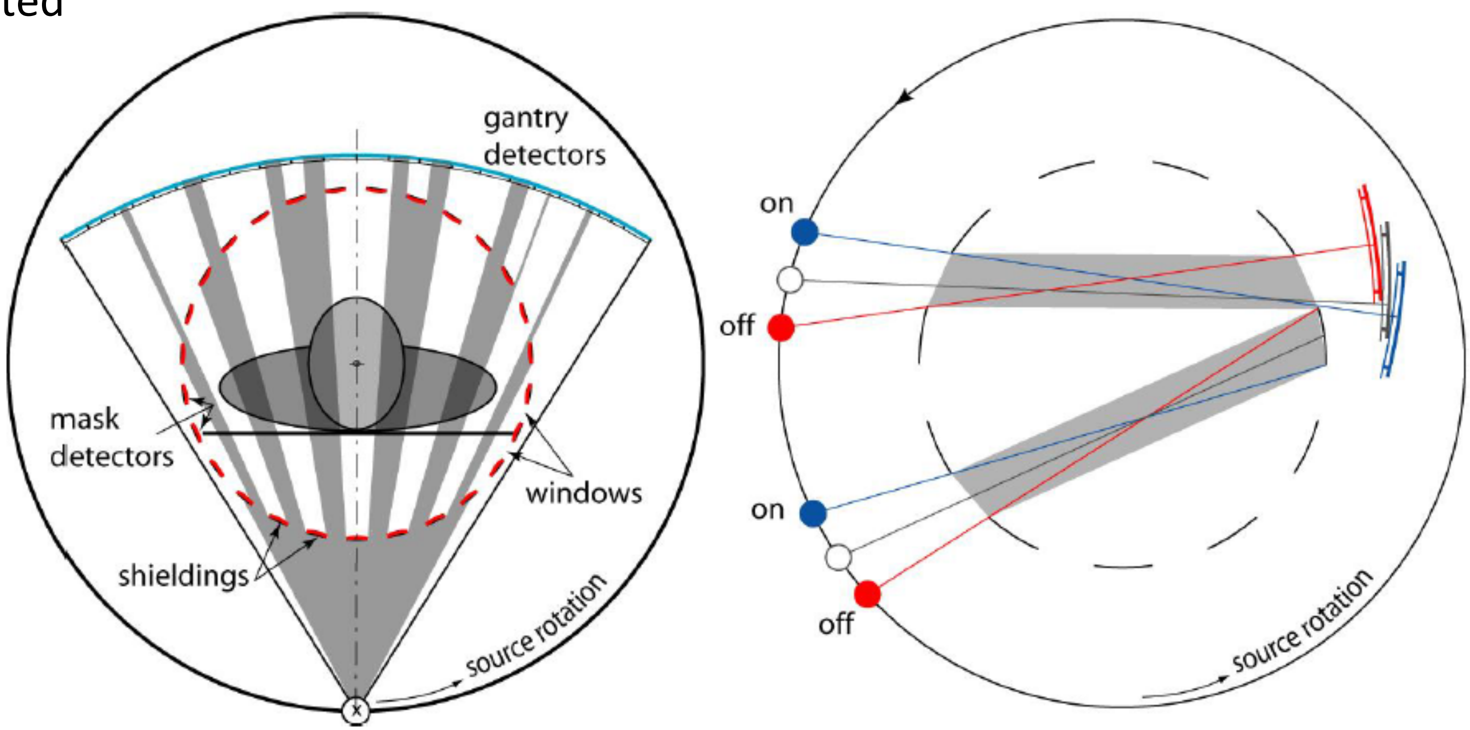
Head: 56 mGy, 1-2 mSv

Efficient dose reduction: CT D ʻOR = (CT with Double Optimal Reading)

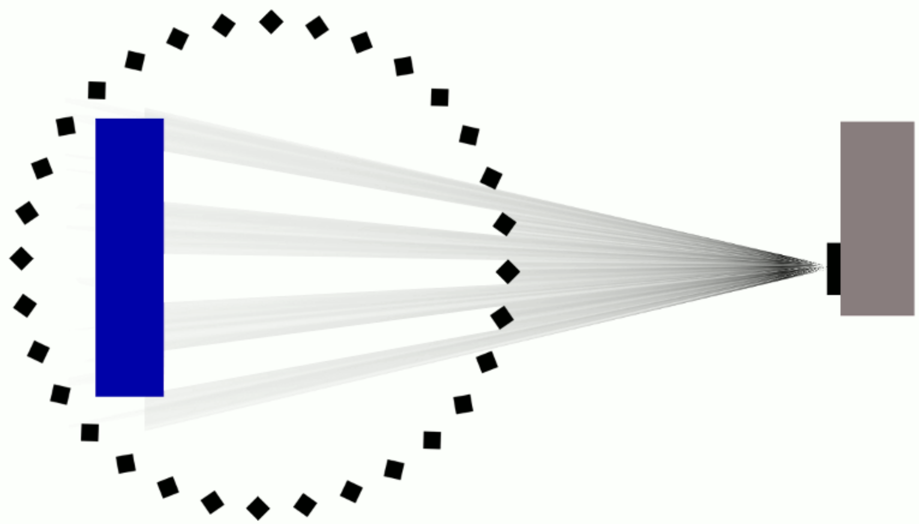
additional detector mask:

X-rays not shielded are detected by mask detectors

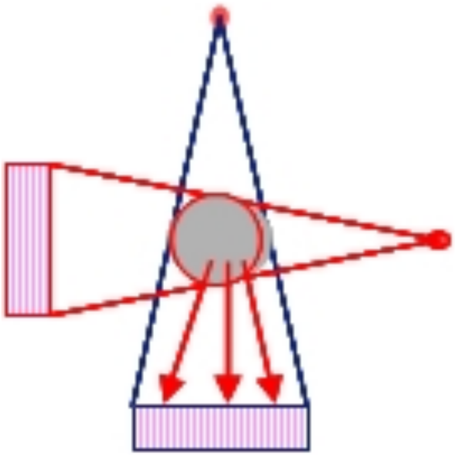
Then both image data (from CT detector and mask detectors) are combined and reconstructed

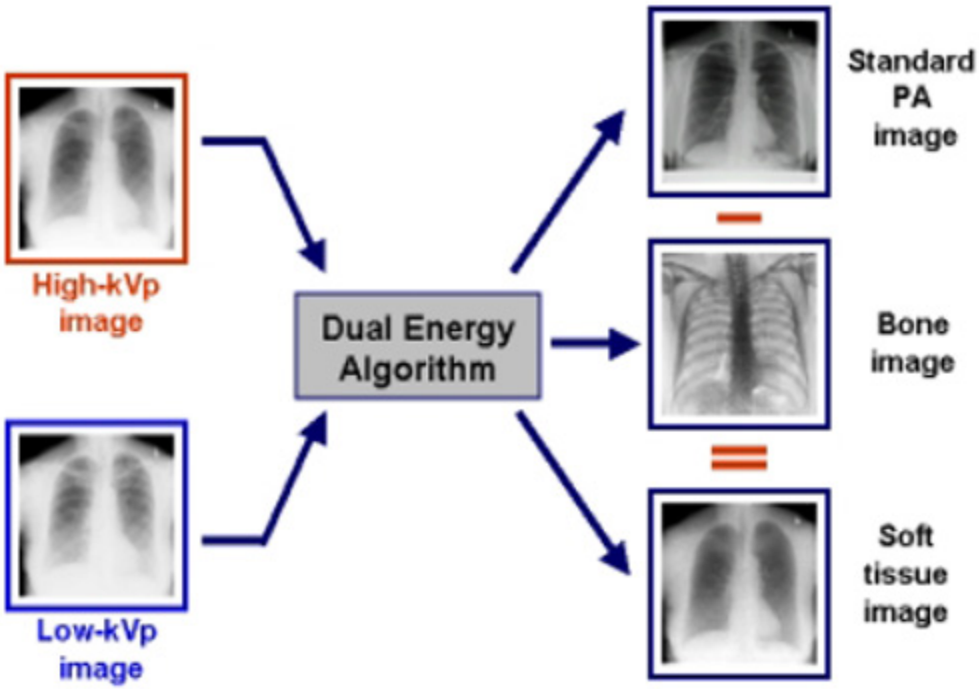


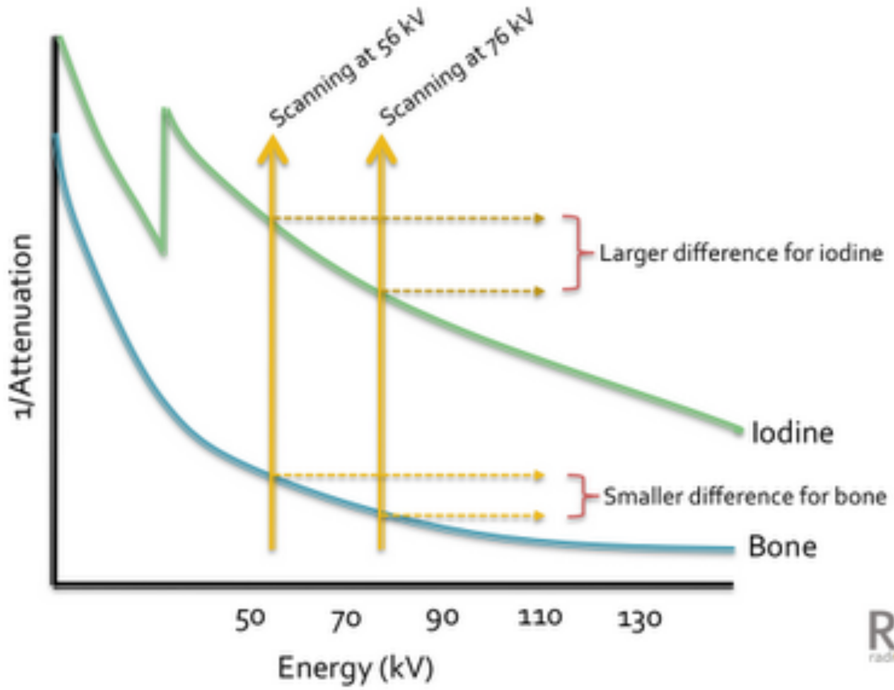
09)



Dual source / dual energy







CT summary

- CT gives 3D information
- can be operated with dual energy
- resolution as low as 0.3 mm – but then dose is issue
- relation between spatial resolution and dose
- new methodes for dose reduction