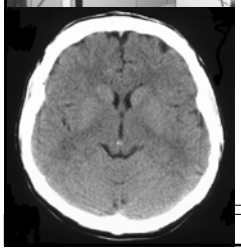

Basic principles of Computed Tomography

CT scanning and imaging parameters

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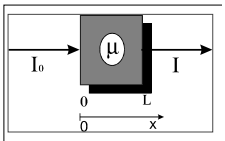
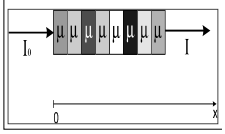
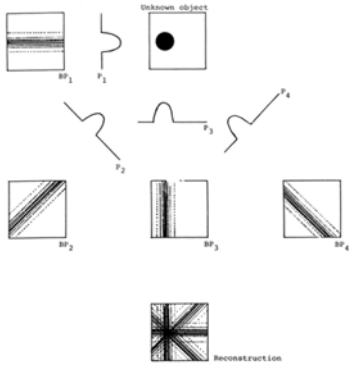


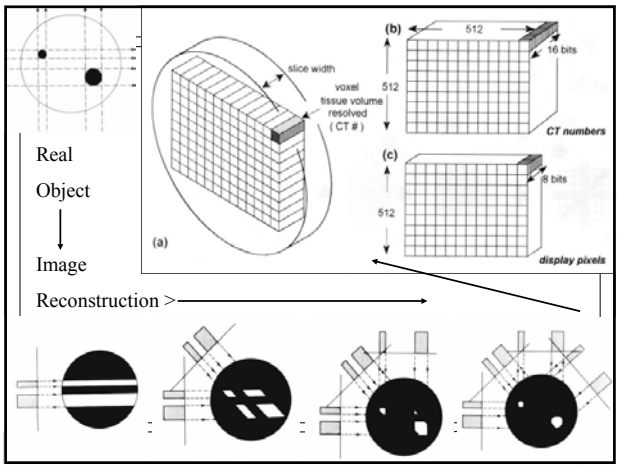
? How to visualise all parts of a "closed" 3D object ?

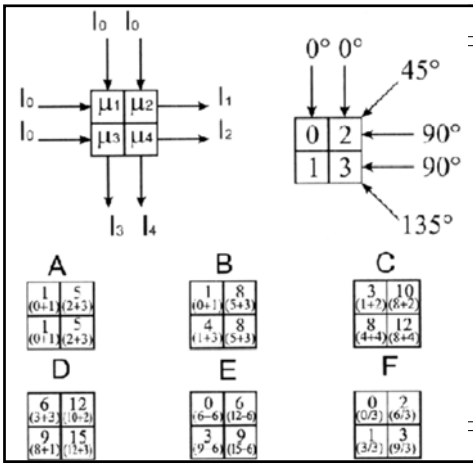
-voxel: elementary volume

-pixel: element of the image

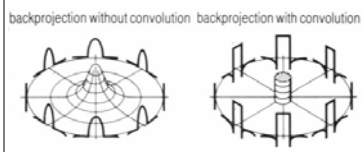


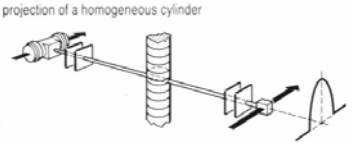






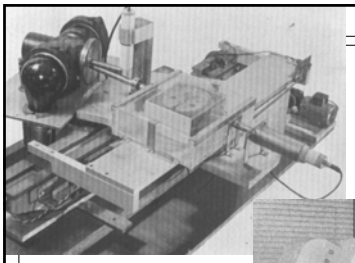
A simple example of reconstruction based on data from 4 angles (projections)





CT image is a product of complex calculation based on backprojection reconstruction algorithm.

The CT image is not a real "shade" like in classical Radiography, but a picture which represents with some probability (>95%) the similarity between the real object and its calculated CT image.



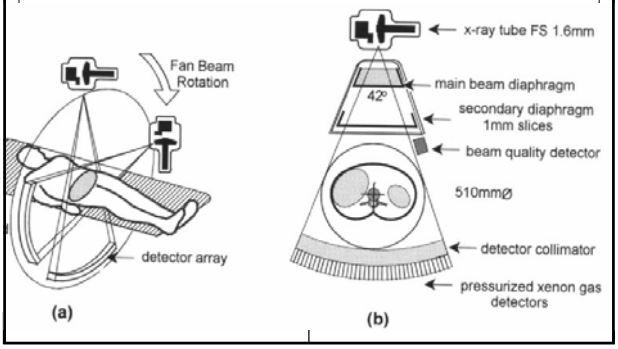
Mathematical theory (Radon,1917)

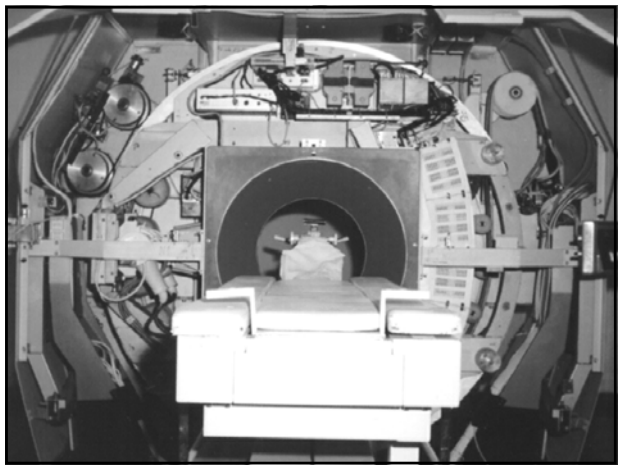
Applications in astronomy (1950)

First CT experimental set (1960)

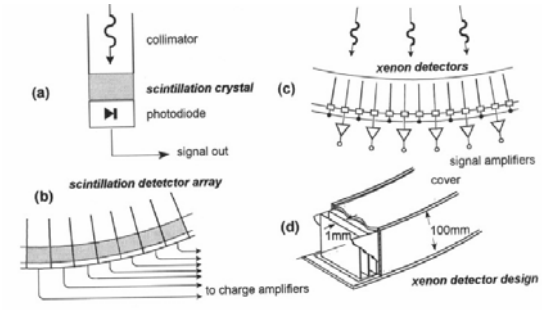
The first CT (EMI MARK1) and Sir Hounsfield - 1973

Typical III generation CT scanner

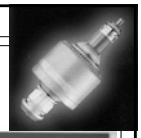


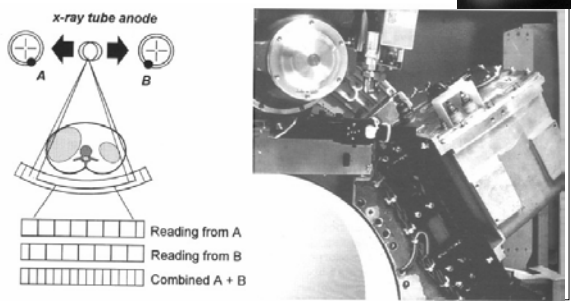


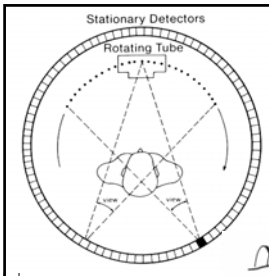
CT detectors development - solid state and gas (Xe) filled
Increased detector efficiency and new (III) generation scanners



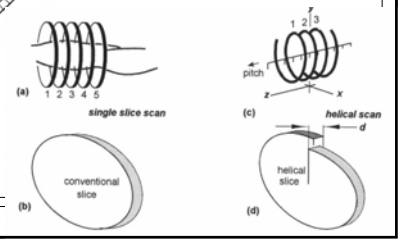
Increase spatial resolution using powerful new
X-ray tubes with flying focal spot technology

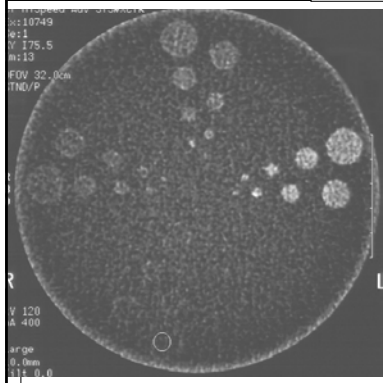






Typical IV generation CT scanner
and Spiral (Helical) CT scanning





CT contrast resolution is one of the dramatic advantages of the method, compared with classical radiography.

CT discriminates density difference ~ 0,25-0.5 % while normal Radiography discriminates ~ 10%

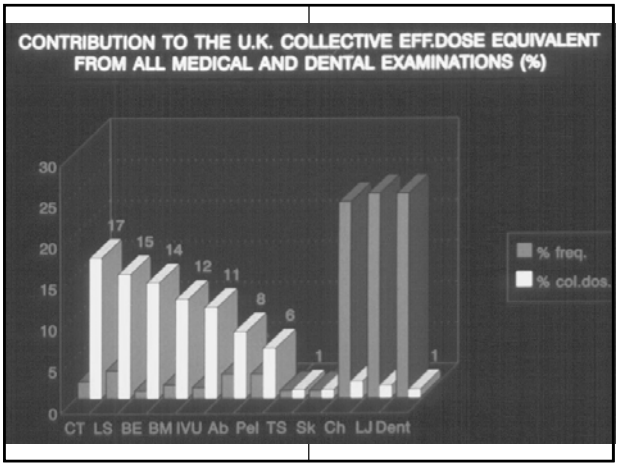
CT spatial resolution is limited by the image matrix size, detectors and algorithm

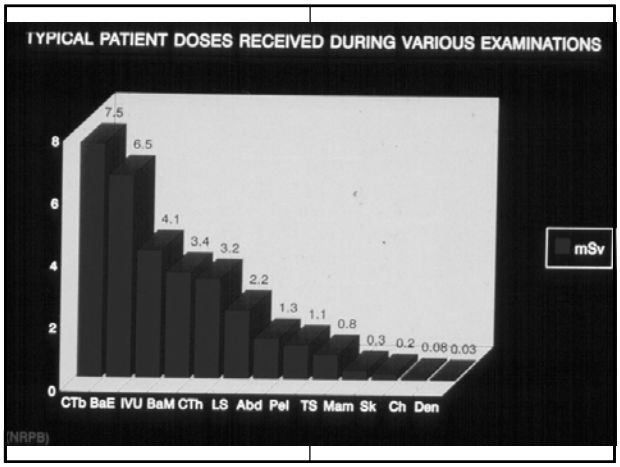
CT dose to the patient is the main disadvantage of the method

CT dose is 10-20 times higher than this in classical Radiography.

COLLECTIVE DOSE TO THE POPULATION OF U.K. FROM DIAGNOSTIC MEDICAL RADIOLOGY (man Sv)

Medical X-rays (excl. CT)	15500
Computed tomography (estimated)	500
Dental X-ray	200
Nuclear medicine	950
TOTAL (man Sv) : 17150	

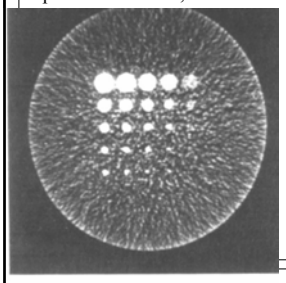




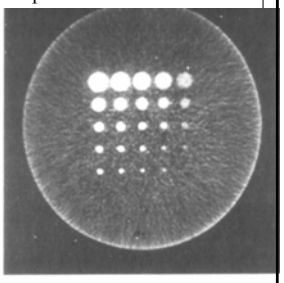
Basic Scanning parameters

- kV, mA (mAs) - the increase of these:

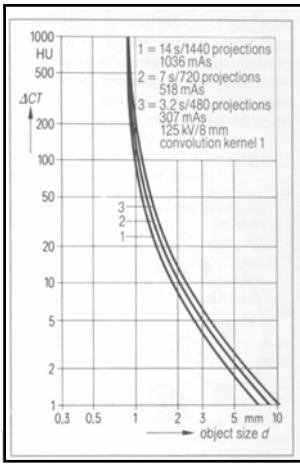
increases the contrast resolution (decreases the noise), hence the spatial resolution , but also increases the patient dose



10 mGy



80 mGy



Basic Scanning parameters

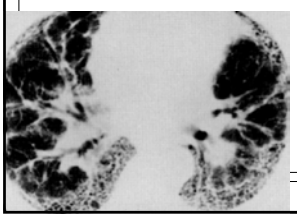
- Scan time (number projections) - the increase of these:

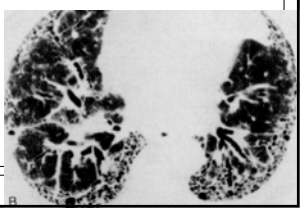
increases the resolution (both high contrast and low contrast), but also increases the patient dose

Basic Scanning parameters

- Slice thickens - its increase:

decreases the spatial resolution (both in X-Y and Z direction) and increases the patient dose (might increase slightly the contrast of large homogeneous objects)





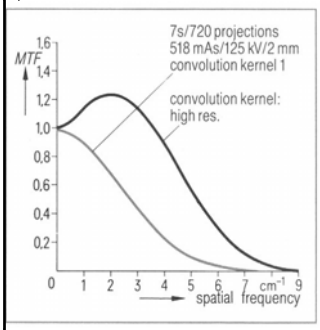
Basic Scanning parameters

Field of View (FOV)

Also Basic Imaging parameter.

FOV/matrix size = pixel size

Its increase leads to increase of pixel size, hence decrease of spatial resolution.

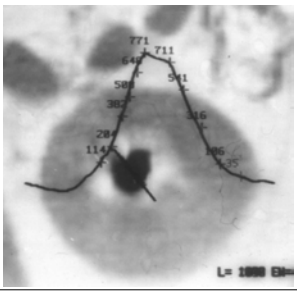


Basic Imaging parameters

Reconstruction algorithm

also Basic Scanning parameter

The HF algorithm increase high spatial resolution, but also increases the noise, hence decreases the contrast resolution (all algorithms are different for Head and Body)



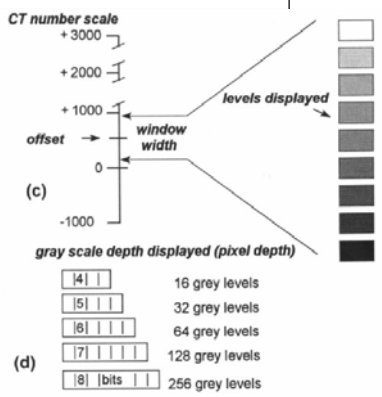
All scanning and imaging parameters (but mainly the algorithm) influence the image contour spread.

This spread is one of the main reasons for un-precise densitometry of small objects.

Basic Imaging parameters

Image filter

The hard filter (HF) filter increase high spatial resolution, but also increases the noise, hence decreases the contrast resolution. The filter is often mistaken with the algorithm, although they lead to similar effects, the filter is applied after the algorithm. The filter can be changed for any image. Soft filtration (LF) increases contrast resolution.

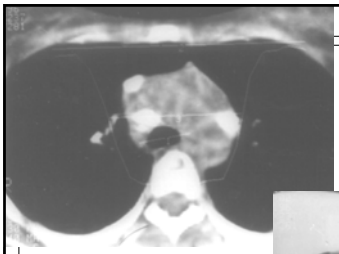


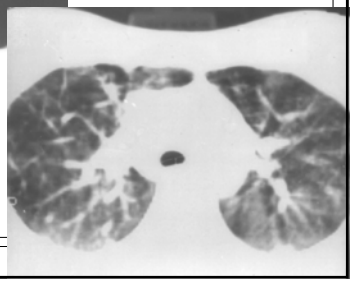
Basic Imaging parameters

Windowing (WW,WC)

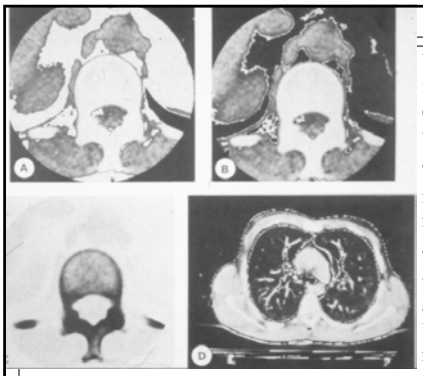
The only technique to allow visual use of the high CT contrast resolution.

Most important for image assessment.





WC changes not only the visualised tissue range, but also the size of the displayed objects (structures)

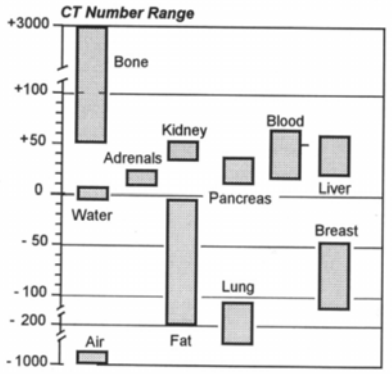


WW, WC, and all image processing changes dramatically the visualisation.

These should be recorded to assure repeatability of results

The calculated pixel values in the memory are not influenced by WW and WC. This is not true for some image processing

$CT_{number} = 1000 . (\mu_{tissue} - \mu_{water}) / \mu_{water}$



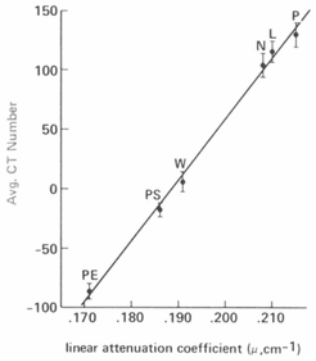
WW and WC should be adjusted for each object (tissue).

Setting WW, WC

1. Measure the object density (HU).

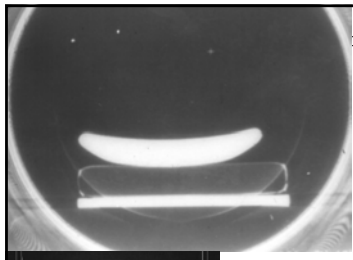
2. Set the WC at this value

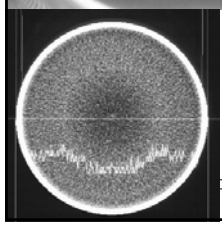
3. Start with narrow WW, enlarging it until best display of the object and its surroundings.



Precise adjustment of the CT Densitometry is performed during the CT calibration (usually made by the CT engineer).

Additional adjustments are made automatically every day (or before each scanning period)





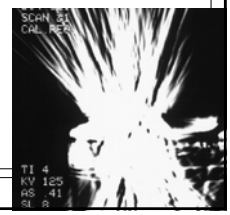
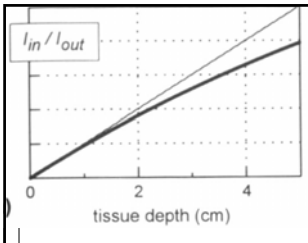
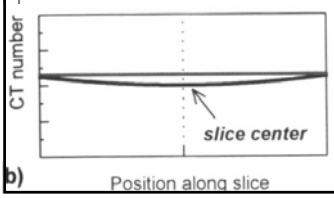


Image Artefacts

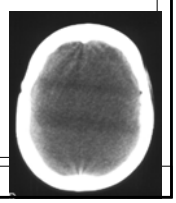
Beam hardening artefact exists in all CT scans (with different intensity)



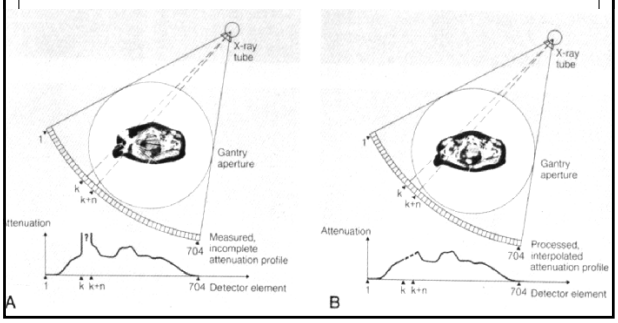


The X-ray beam spectrum changes with the depth of material on its path.

Beam shaping filter is the most often used correction.



Correction of beam hardening (metal artefact) with interpolation of the attenuation profile (from Felsenberg)



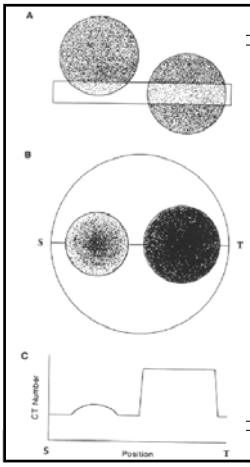
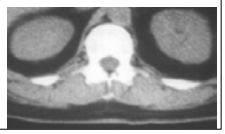


Image artefacts

Partial volume - present in all scans



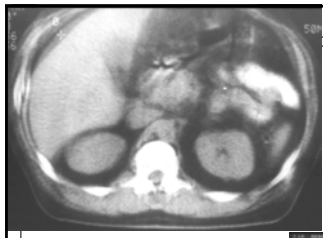
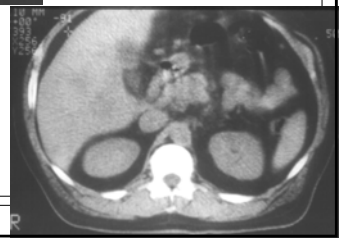


Image artefacts

Motion artefact



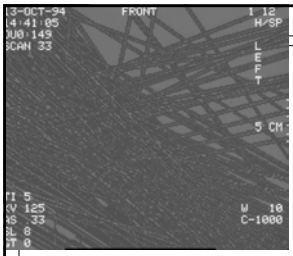
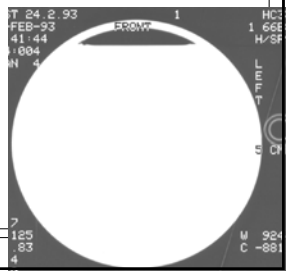
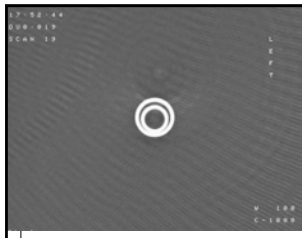


Image artefacts

Problems during data acquisition





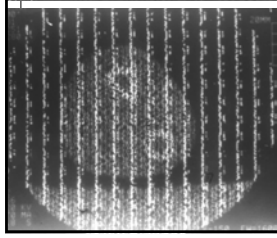


Image artefacts

Mechanical artefact (vibration), often related to old rotation mechanism.

Best seen with low WC.

Image memory problem.