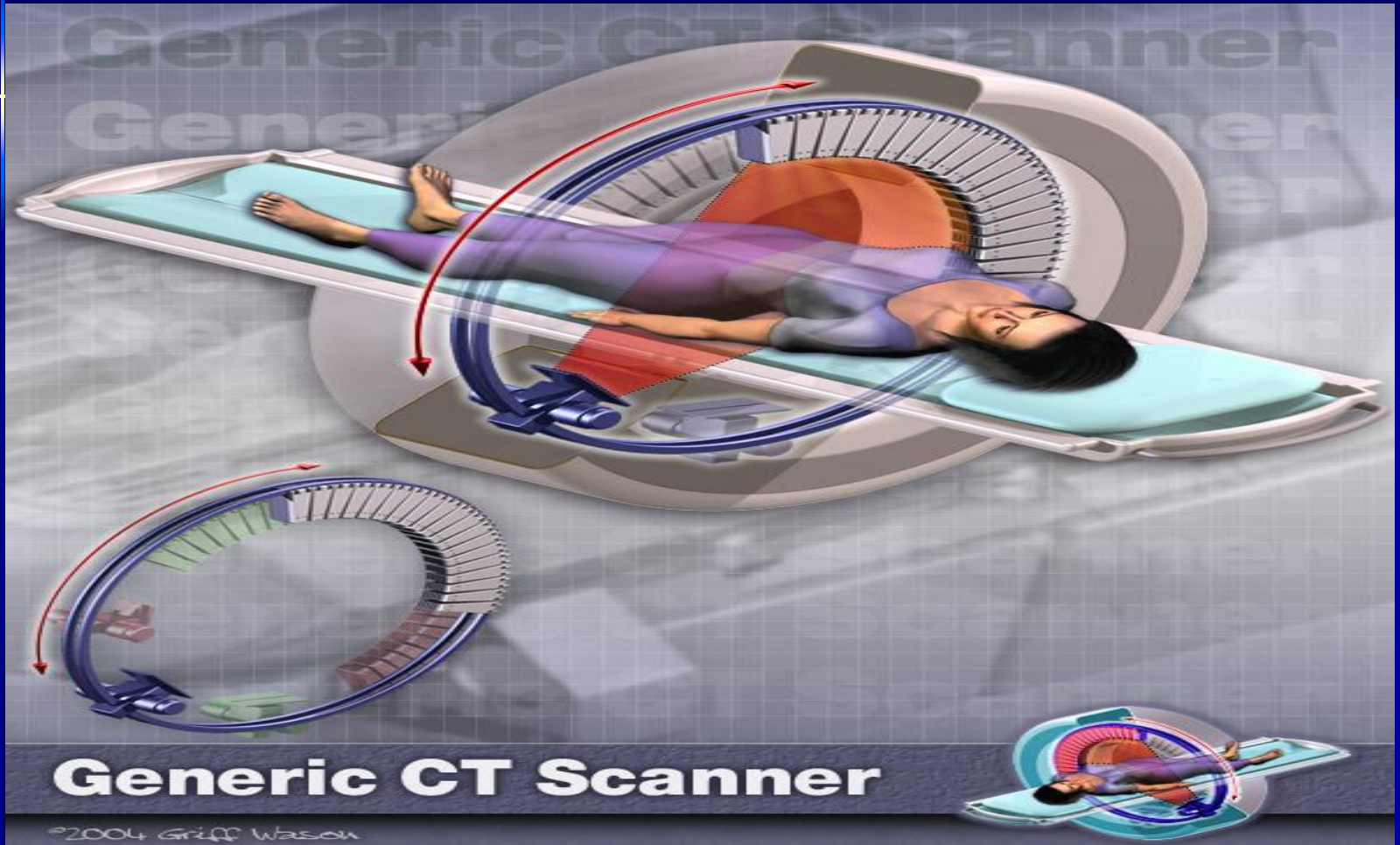




سورة التوبة



PHYSICAL PRINCIPLES OF COMPUTED TOMOGRAPHY



Presentation: **Mohamad Akbarnejad**
Radiobiology and Radiation Protection MSC

Resolution:

❖ **Spatial resolution**

❖ **Contrast resolution**

❖ **Temporal resolution**

Spatial Resolution

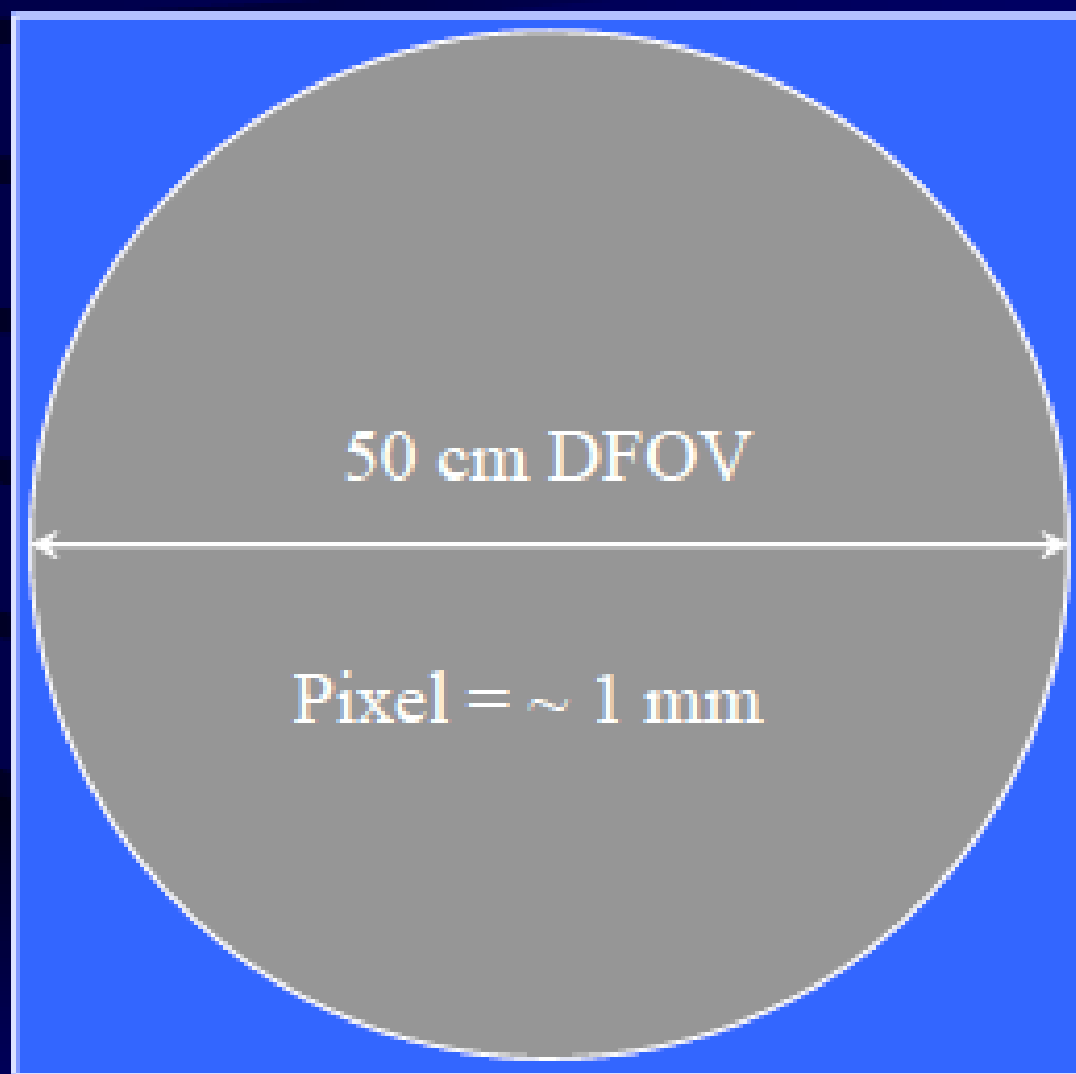
Ability to detect a small object easily distinguished from background

- Display Field of View (DFOV) size
- Reconstruction filter (algorithm, kernel)
- X-ray tube focal spot size
- Image thickness (blurs edges of objects)
- Pitch (blurs edges of objects)
- Patient motion
- Image zoom

$$\text{Voxel size} = \text{DFOV}/512$$

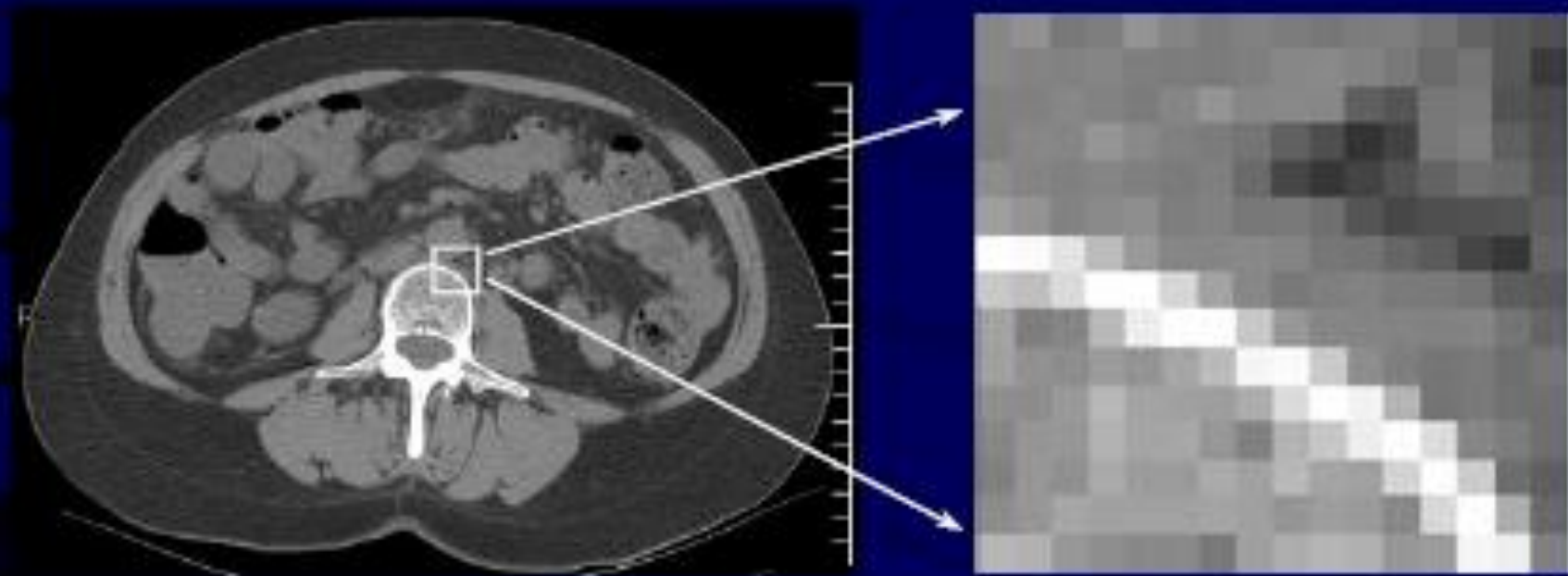
X-Y Voxel Size

512
pixels



512 pixels

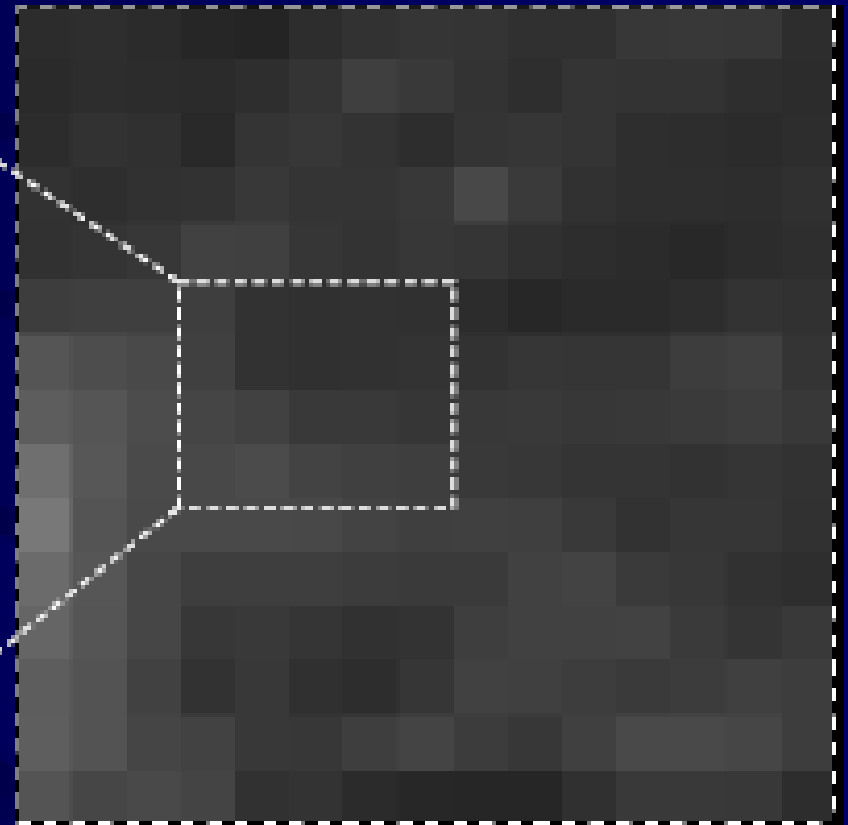
Pixels and Image Matrices



Pixels and Image Matrices

222	220	200	146	103
200	158	127	96	73
207	131	103	82	86
202	126	112	124	133

Pixel Values (HU)



Effects of Recon Filters on Resolution & Noise



Std Recon



Soft Recon

Effects of Recon Filters on Resolution & Noise



Std Recon



Bone Recon

Effects of Recon Filters on Resolution & Noise



Std Recon



Detail Recon

Effects of Recon Filters on Noise

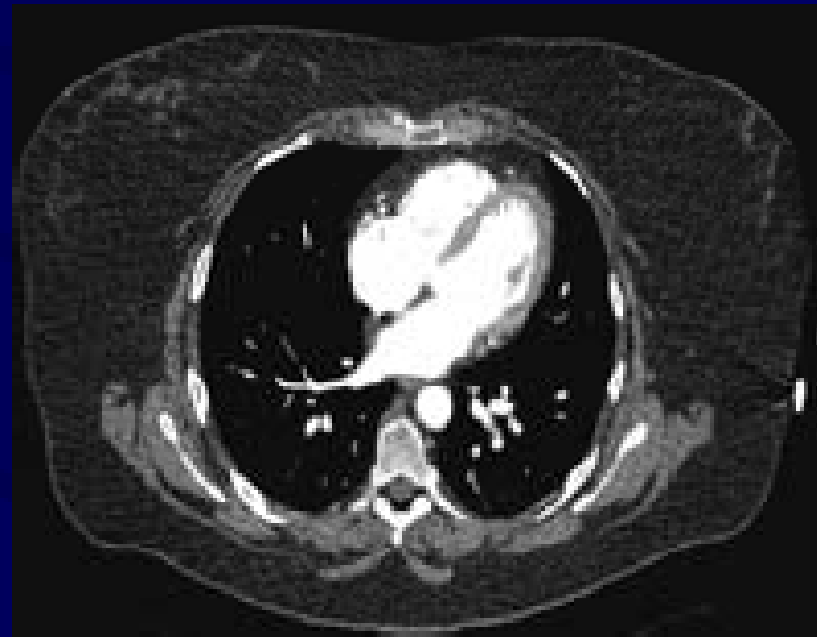
Recon Filter	Std Dev Water Img
Soft	3.8
Standard	4.7
Lung	19.6
Detail	6.5
Bone	18.8
Edge	35.8
Bone Plus	27.0



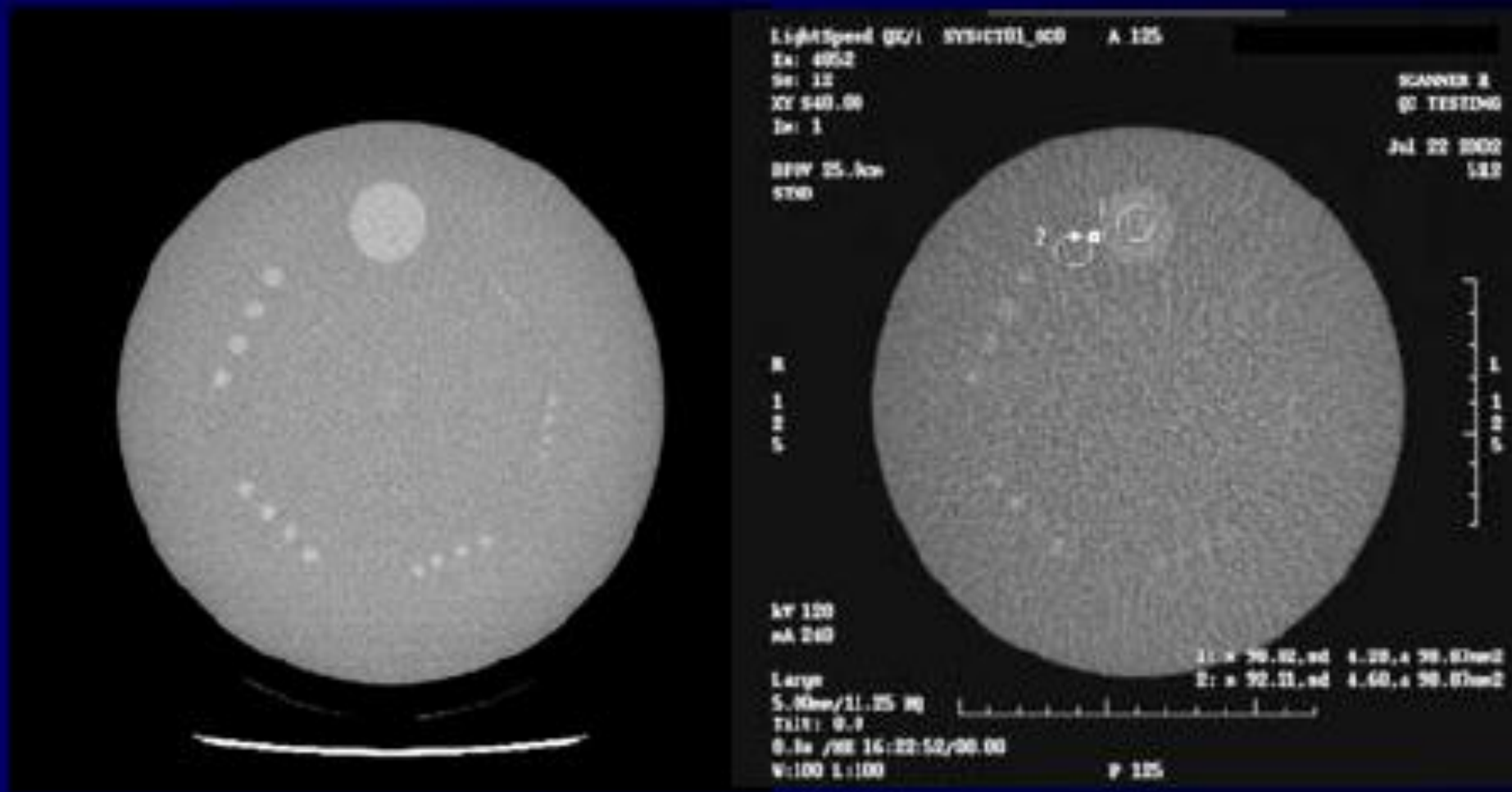
Contrast Resolution

Ability to see a small object not easily distinguished from background (NOISE)

- Effective mAs
 $\text{mA} * \text{time} / \text{pitch}$
- Image thickness
- Patient size
- Reconstruction filter
- Viewing conditions



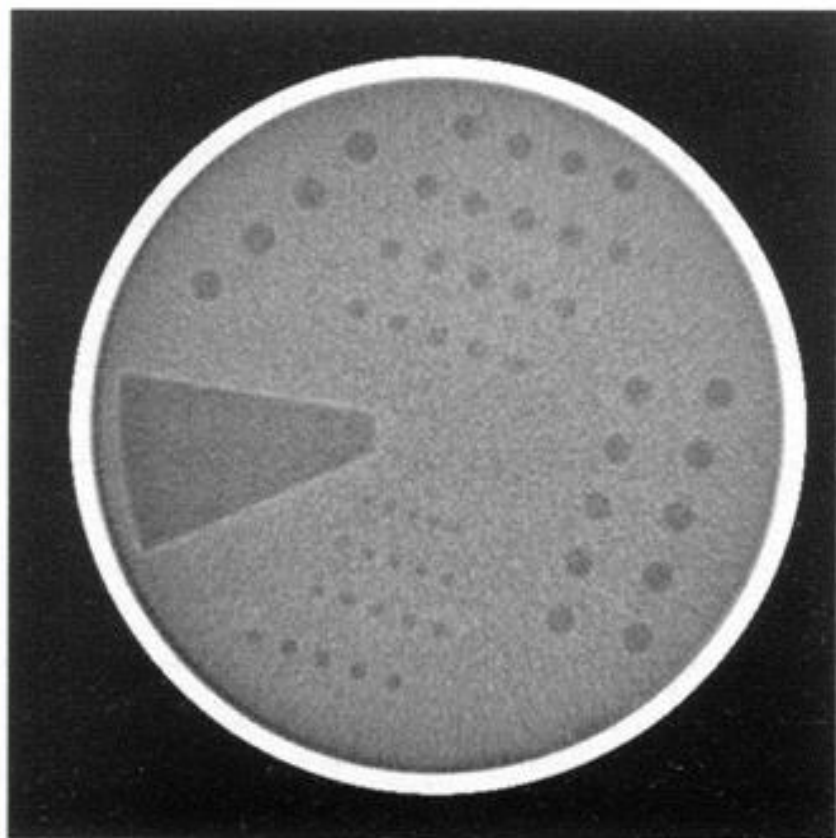
ACR Phantom - Low Contrast Section



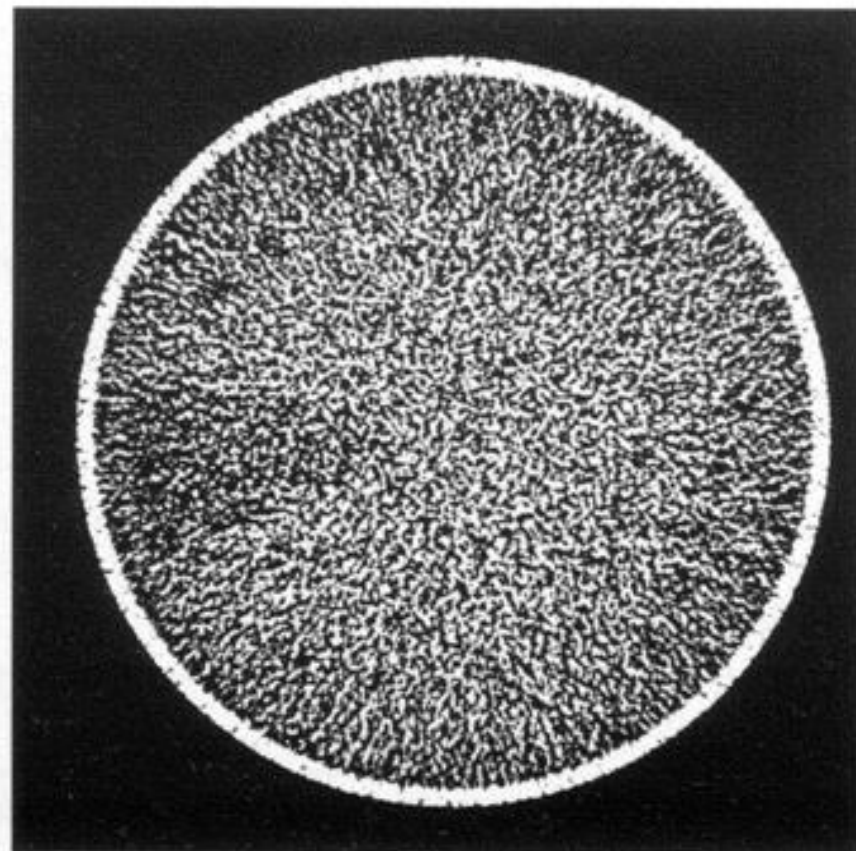
120 kVp, 1600 mAs

120 kVp, 192 mAs

High dose scan

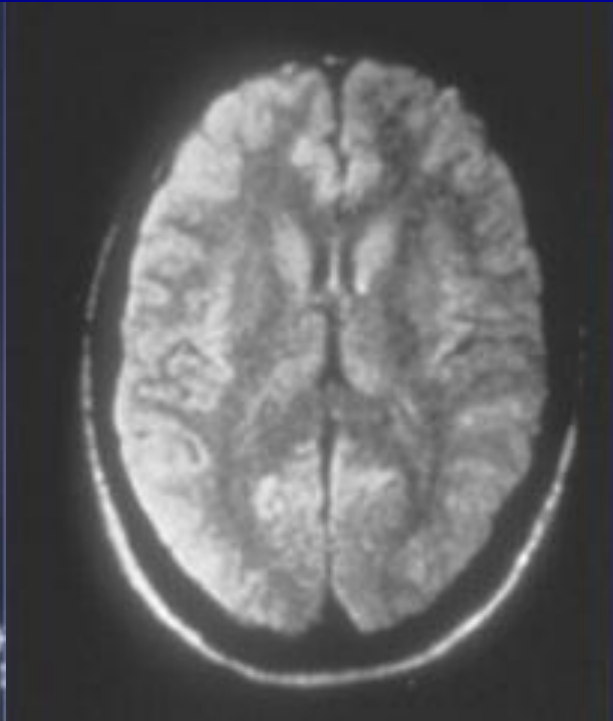
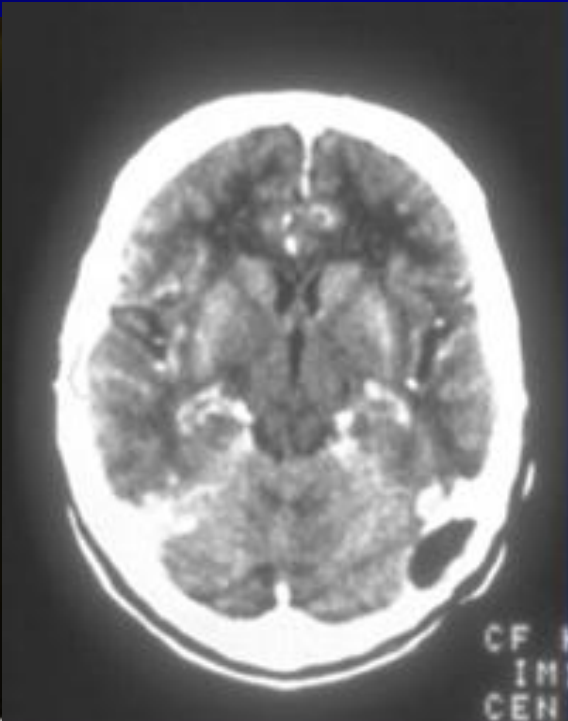


Low dose scan



Viewing Conditions - Contrast

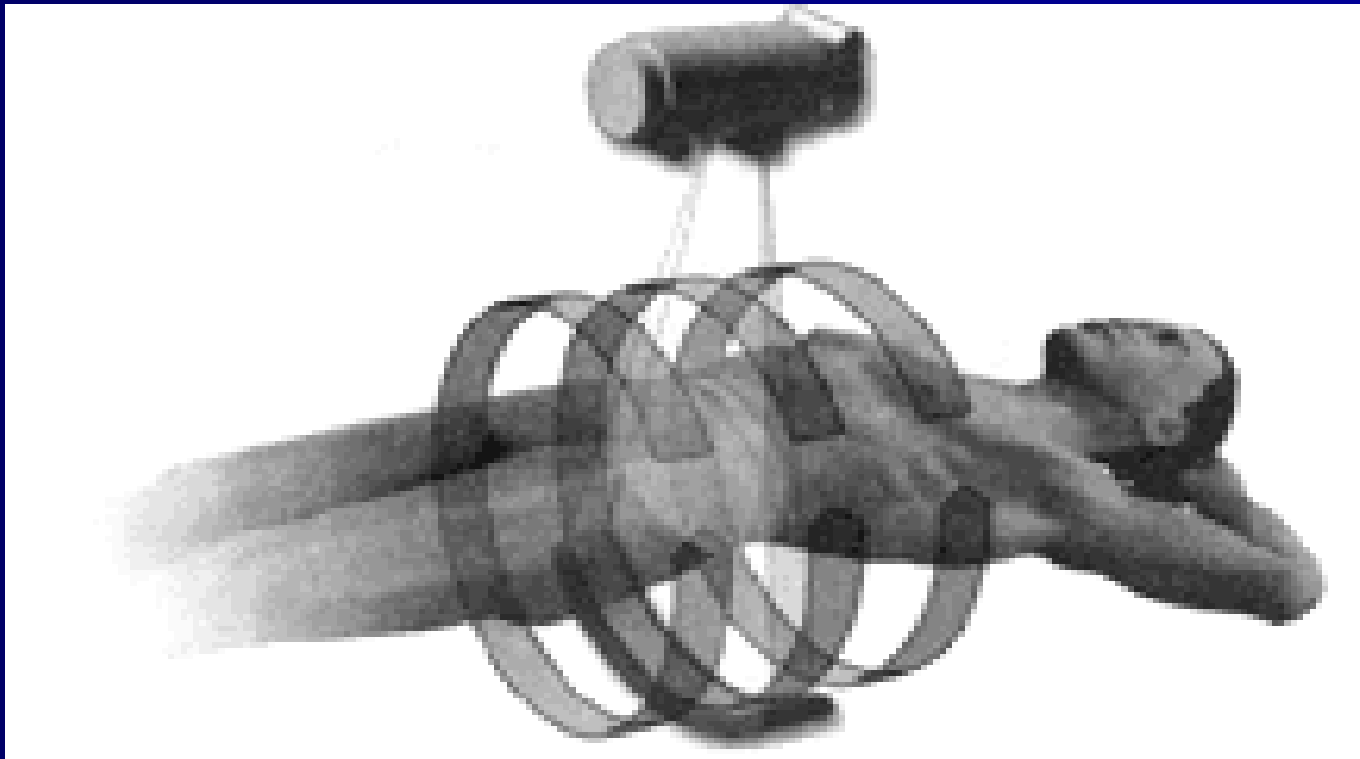
- Distance
- Ambient (room) lighting
 - Cannot see the stars in the daytime
- Monitor brightness
- Reflections
- Viewing angle (flat screens)
- [Age of eyeballs...]



Temporal resolution:

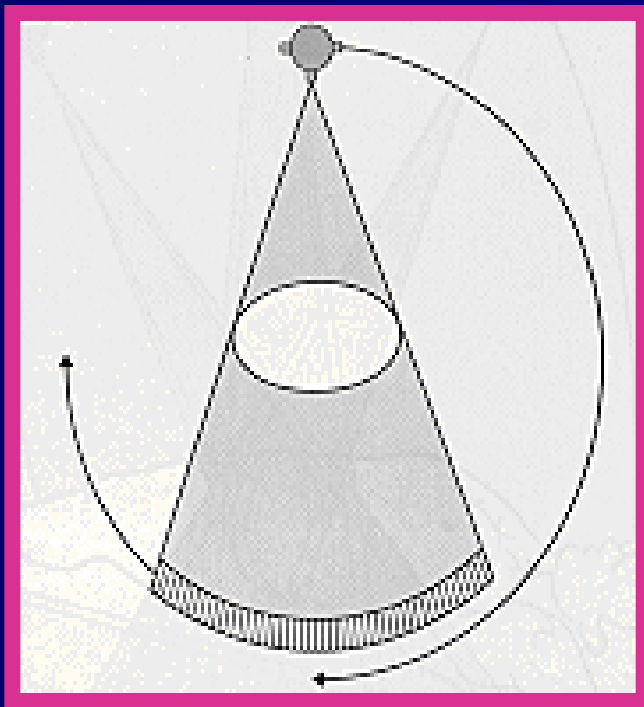
- توانایی سیستم برای متمایز سازی جزئیات یک کمیت سنجشی از نظر زمانی در یک سیگنال را گویند

SEQUENTIAL-SLICE BY SLICE SCANNING

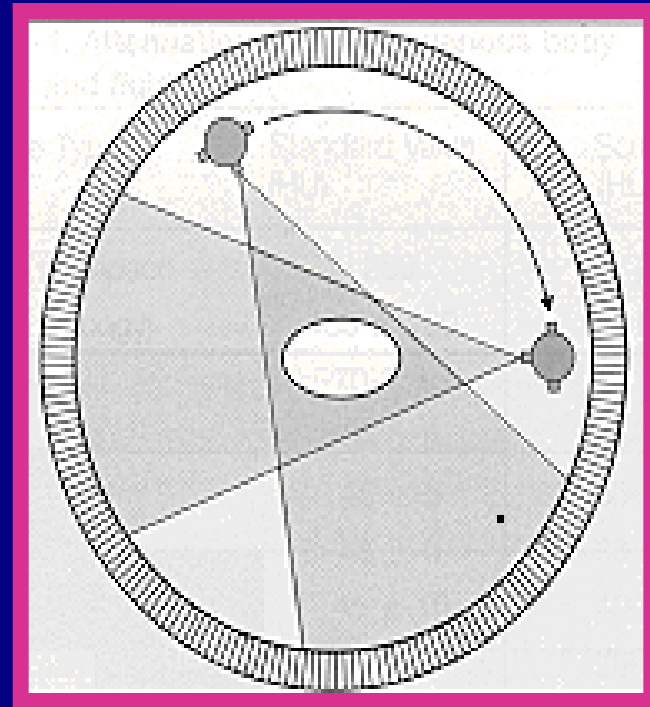


CT Generations

“Generation” is used to label CT tube-detector designs



3rd Generation Design
Rotating tube & detector



4th Generation Design
Fixed ring detector

3rd & 4rd Generation

- Four step process of slice by slice sequential CT scanning

Scanning:

1-Start

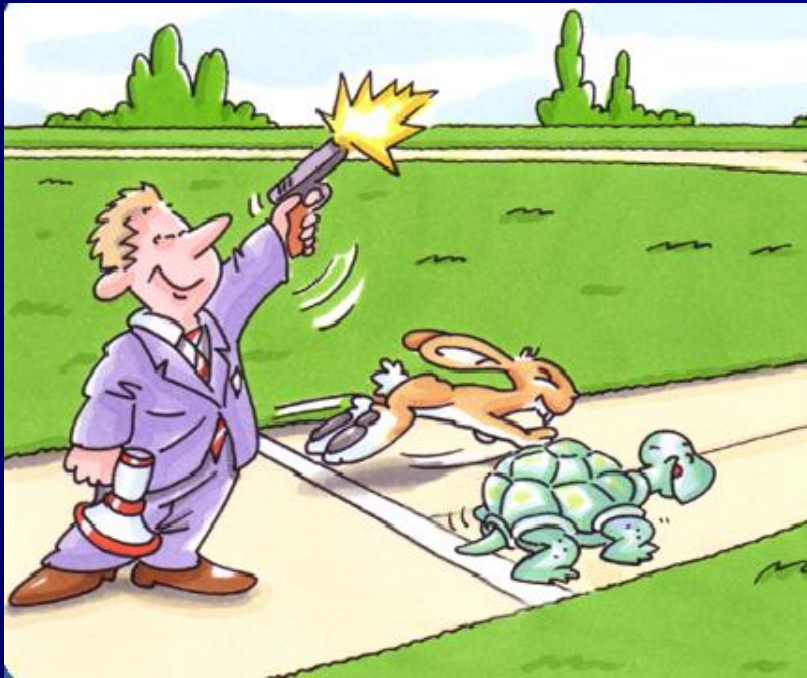
2-Data acquisition

3-Stop

4-Move

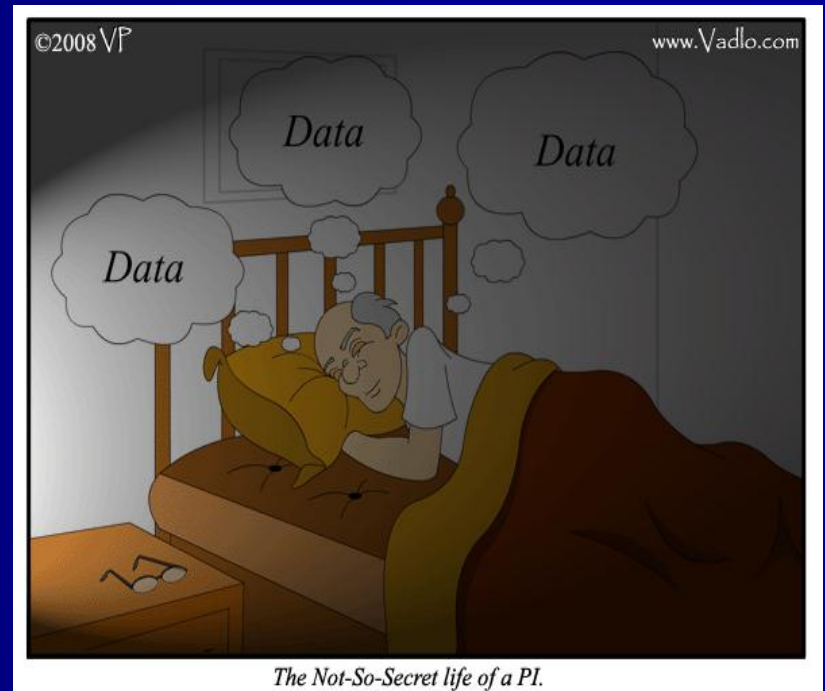
1- START:

Tube & detectors accelerate to a constant speed



2-Data acquisition

X-ray tube energized & data collected for 360 degrees



3- Stop

Stop tube & detectors slow down & stop



4- Move

Tube & patient indexed to the next scanning position

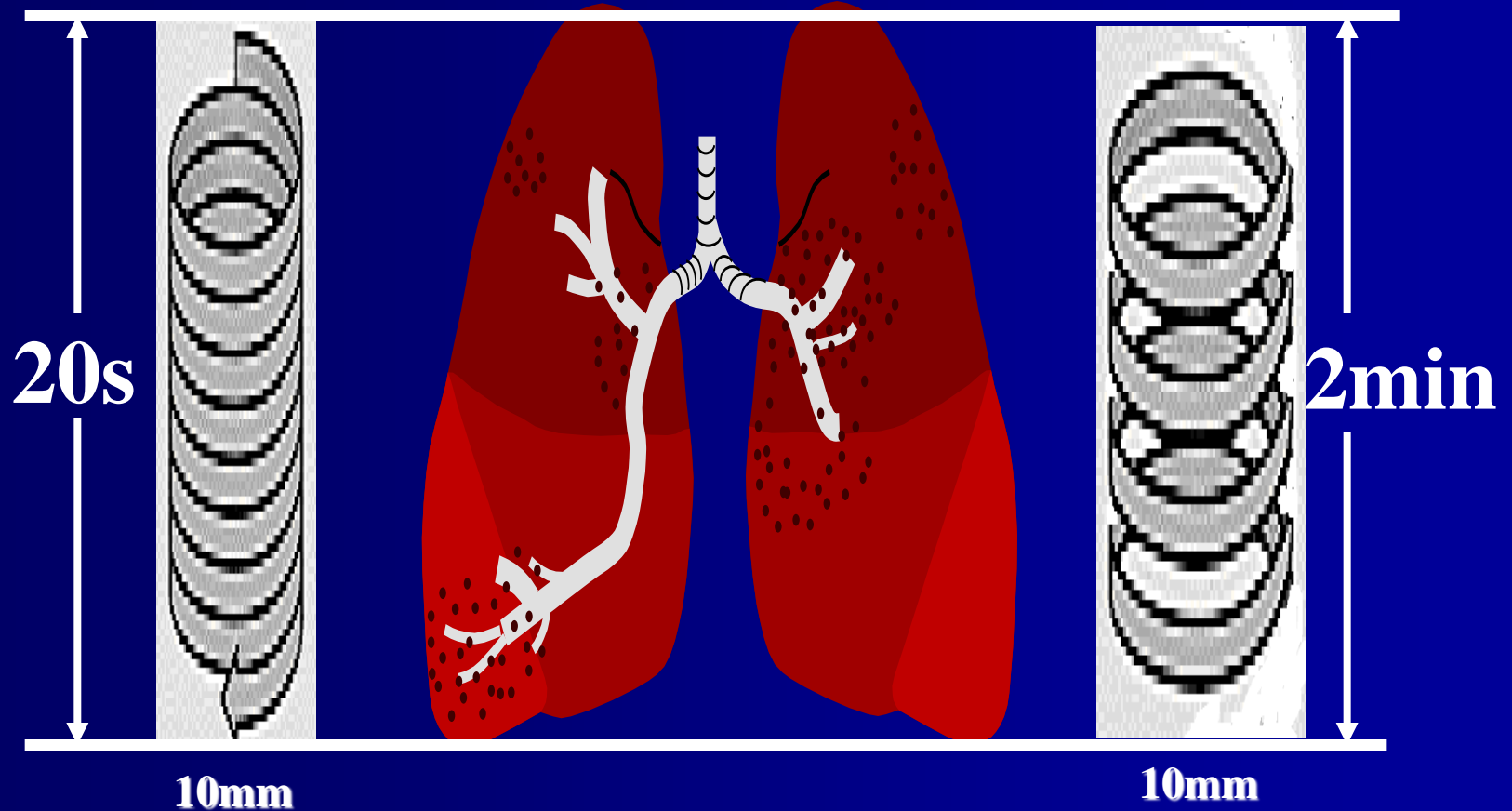


Limitation of slice by slice sequential CT scanning



1- Longer examination time

Scan Range = 300mm



2-Certain portions of the anatomy are omitted because of patient respiration phase

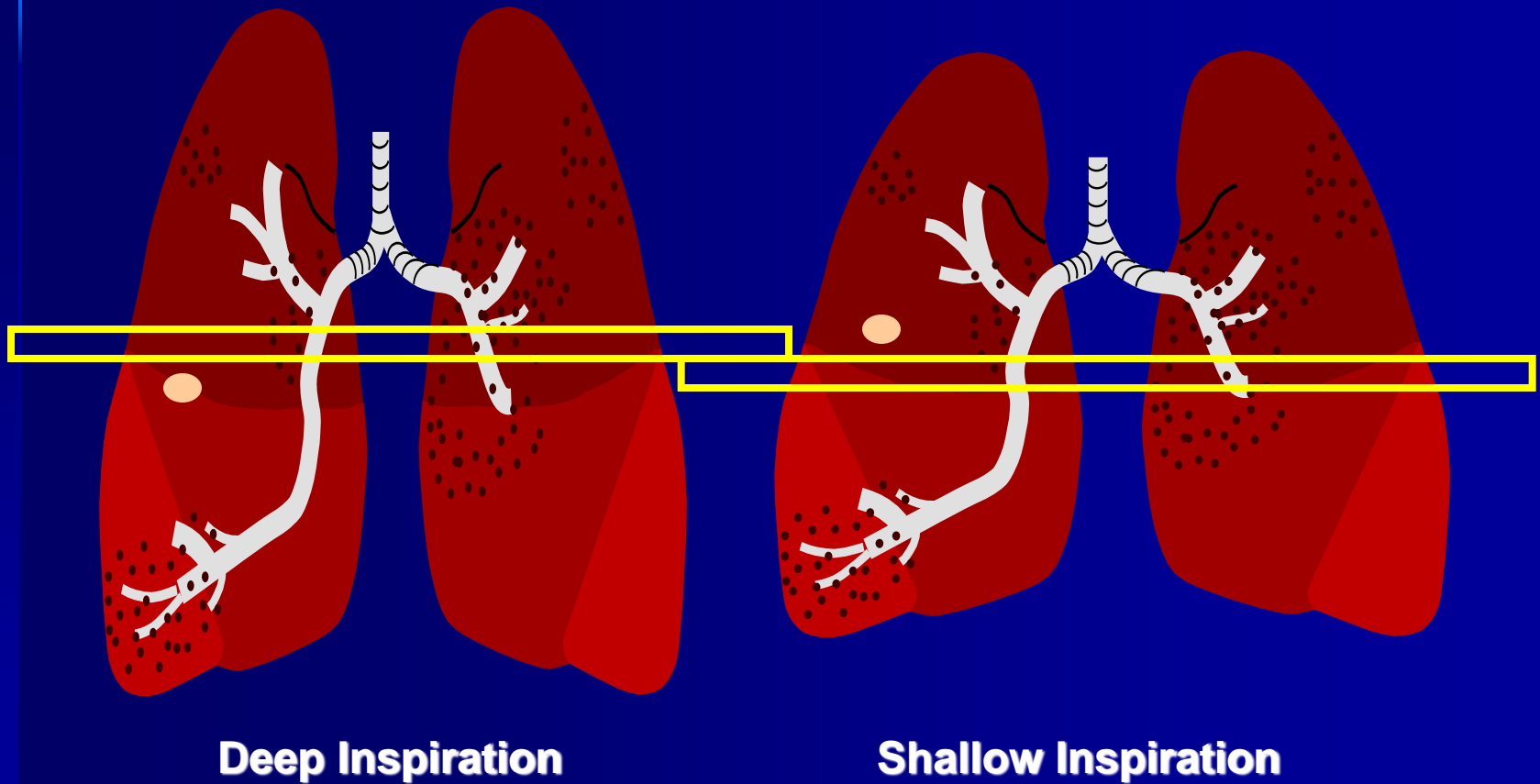
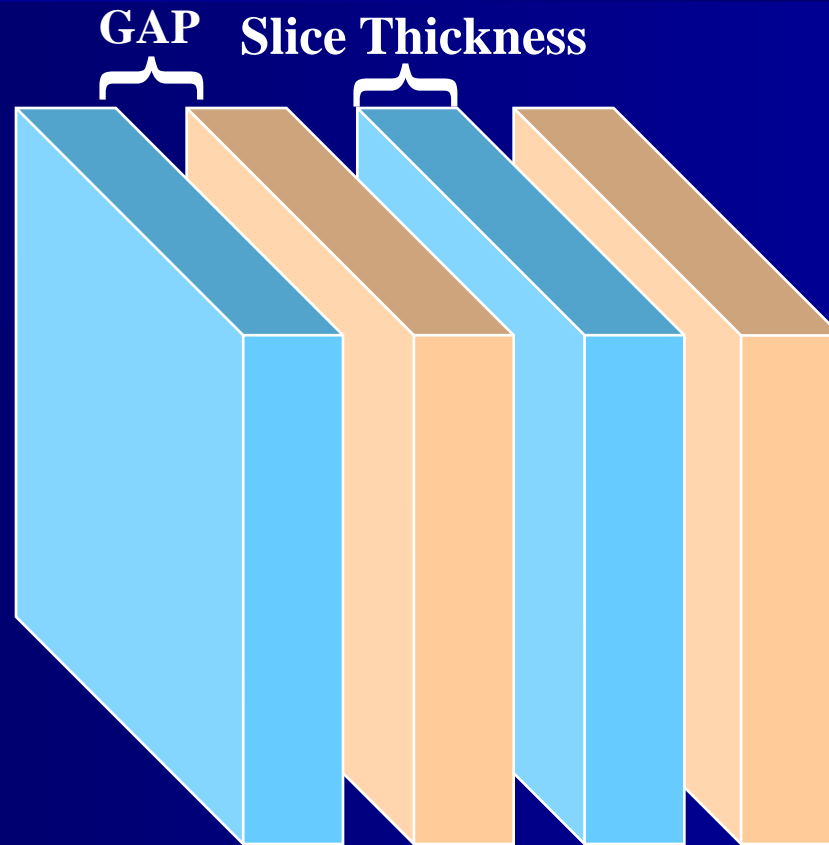
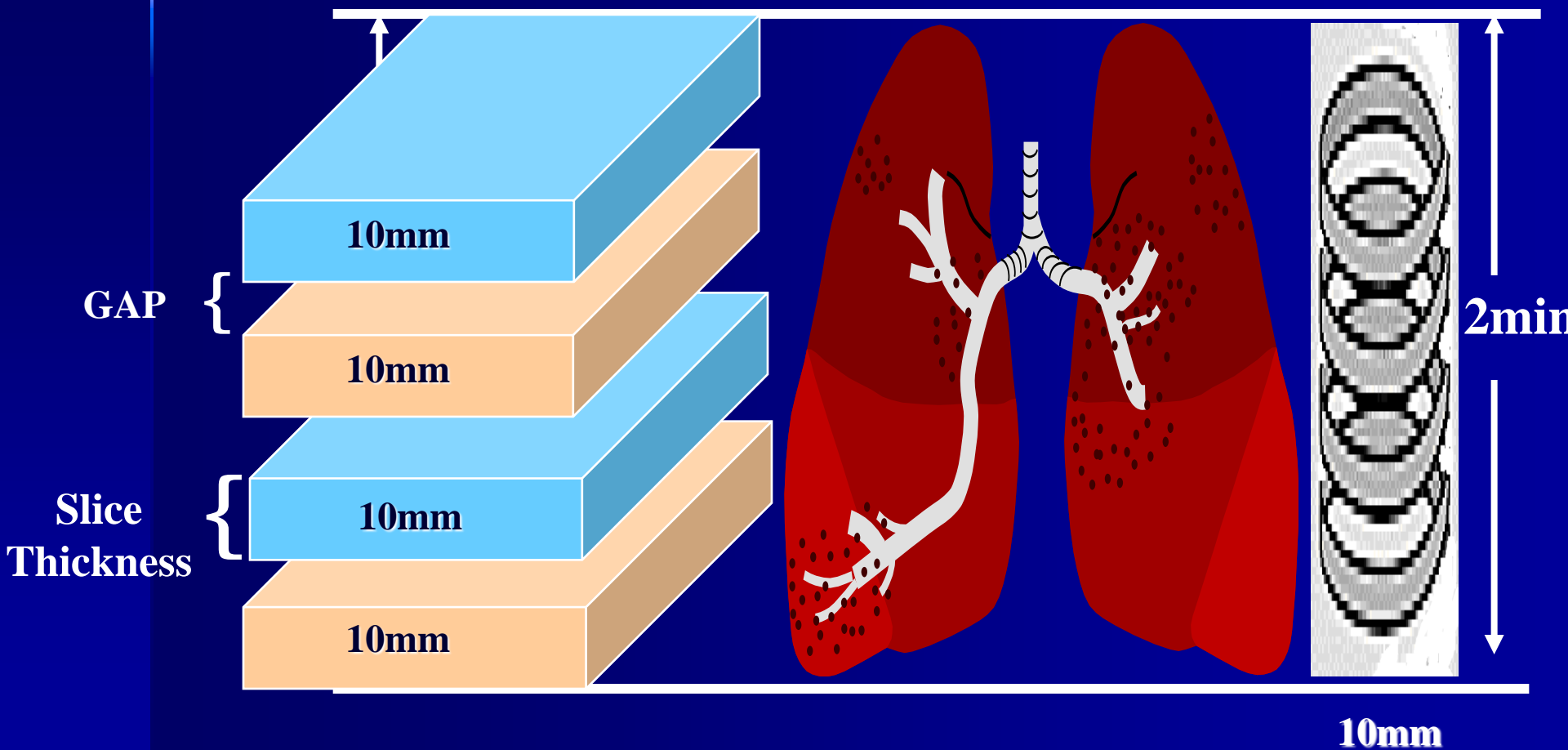


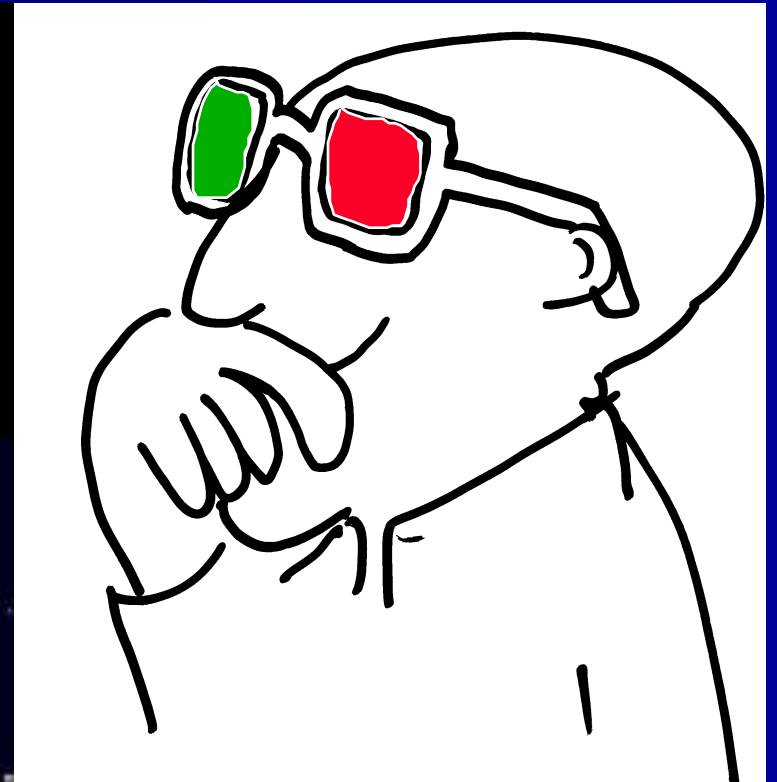
Image Reconstruction with Gaps



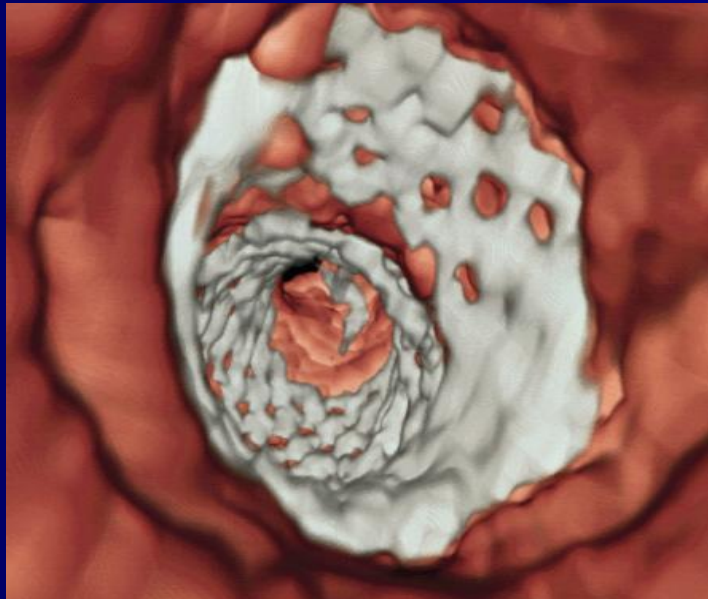
Scan Range = 300mm



3-Inaccurate generation of 3D images



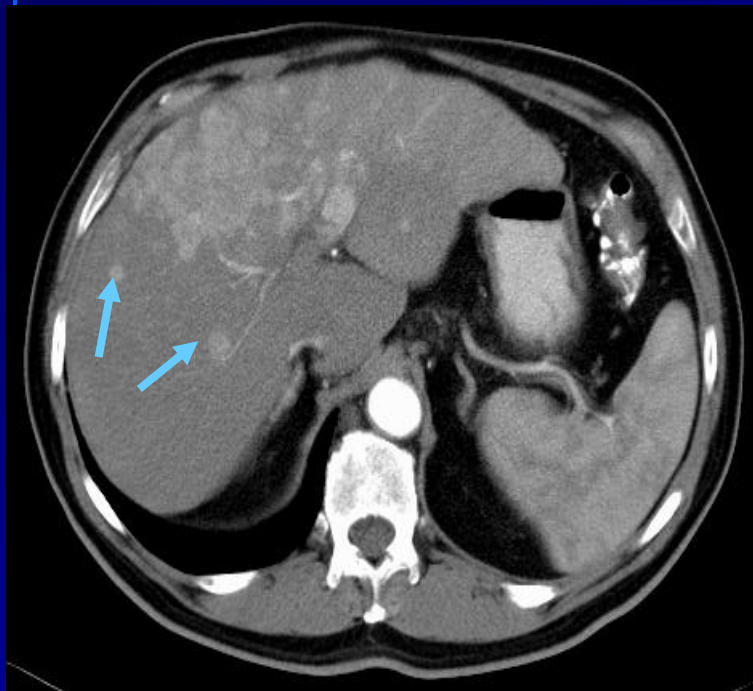
CT Endoscopy



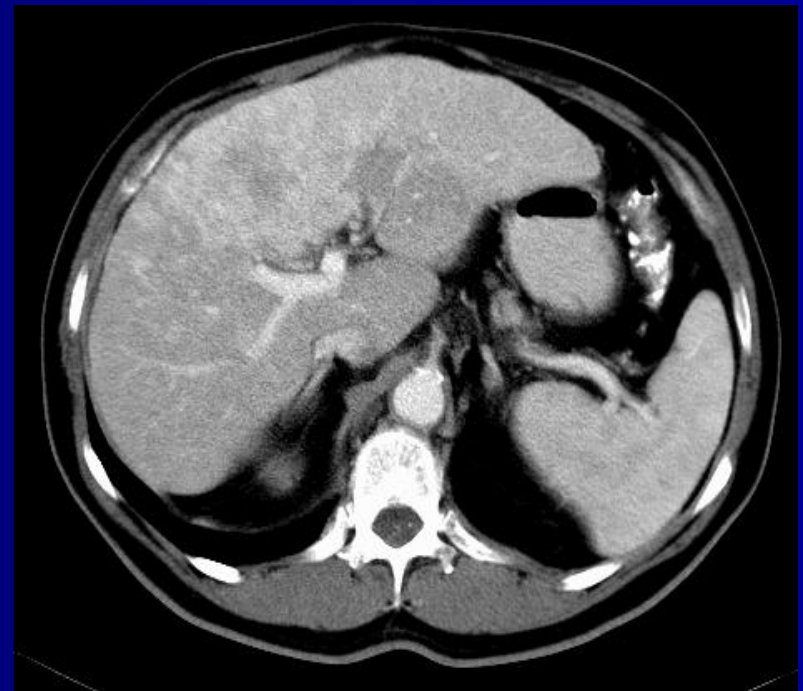
4-Only a few slices are scanned during maximum contrast enhancement when the contrast enhancement technique is useable

Dual Phase Liver Exam

Liver Metastases



□ Arterial Phase



□ Venous Phase

زاویه چرخش	زمان اسکن	
180	6 دقیقه	نسل اول
180	18 ثانیه	نسل دوم
360	0/5 ثانیه	نسل سوم
360	0/5 ثانیه	نسل چهارم

Scanning:

1-Start

2-Data acquisition

3-Stop

4-Move

ISD: inter scan delay

ISD is dead time

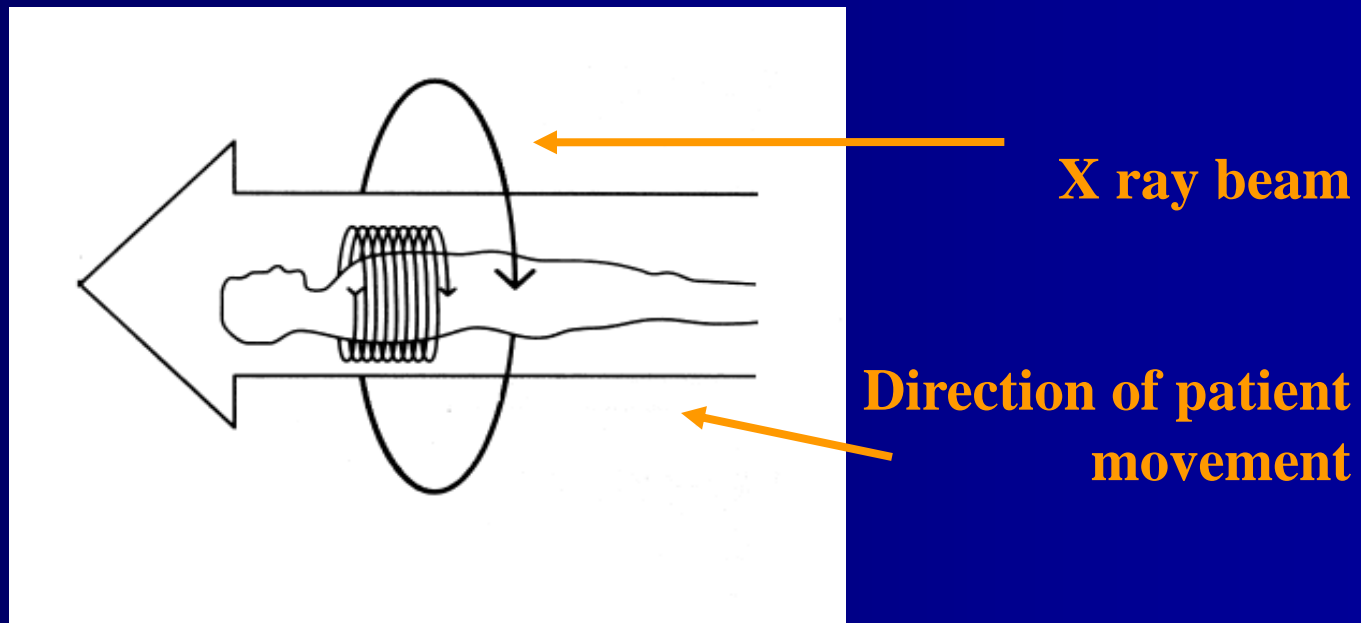


What can be done to omission ISD in CT sequential?



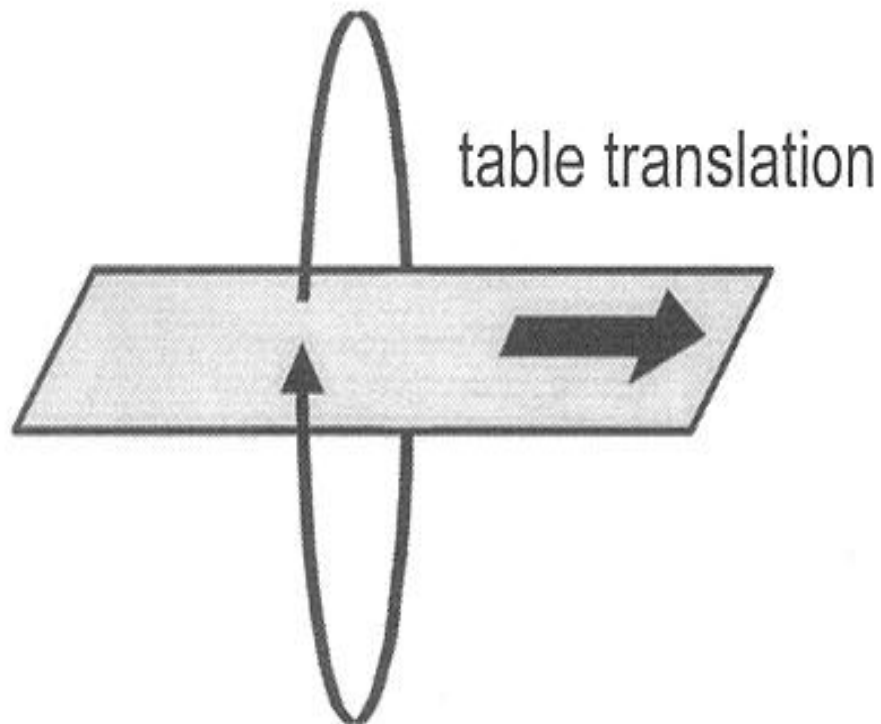
Helical Scan Principle

■ Scanning Geometry

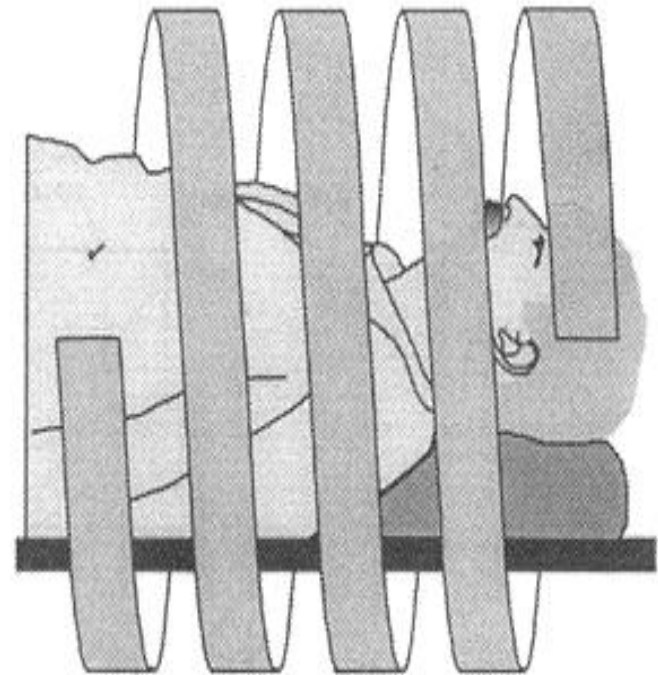


■ Continuous Data Acquisition and Table Feed

Spiral CT scan

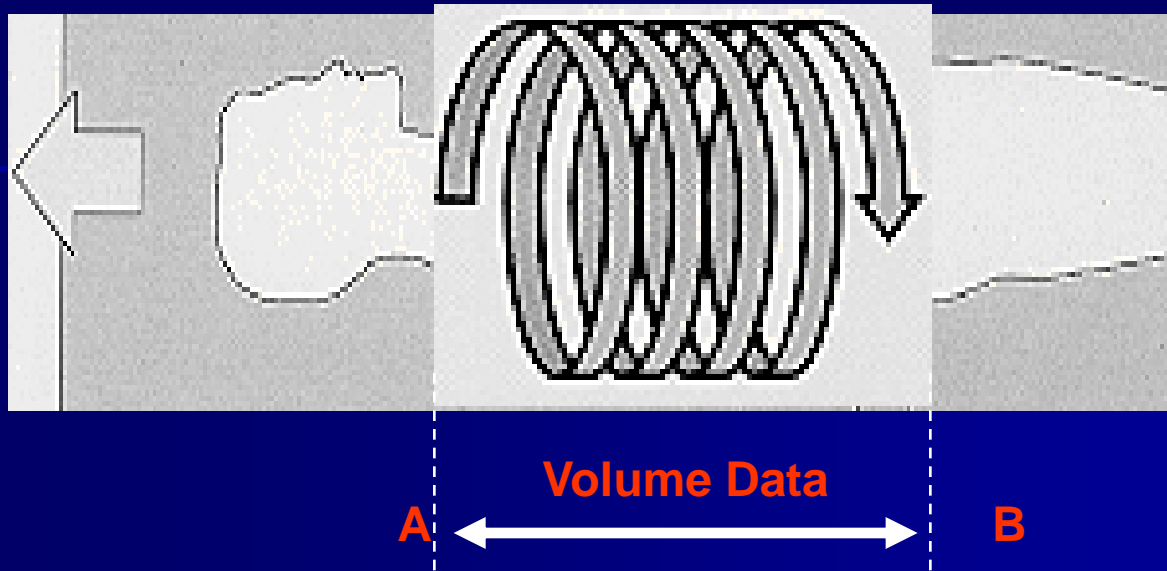


x-ray tube rotation



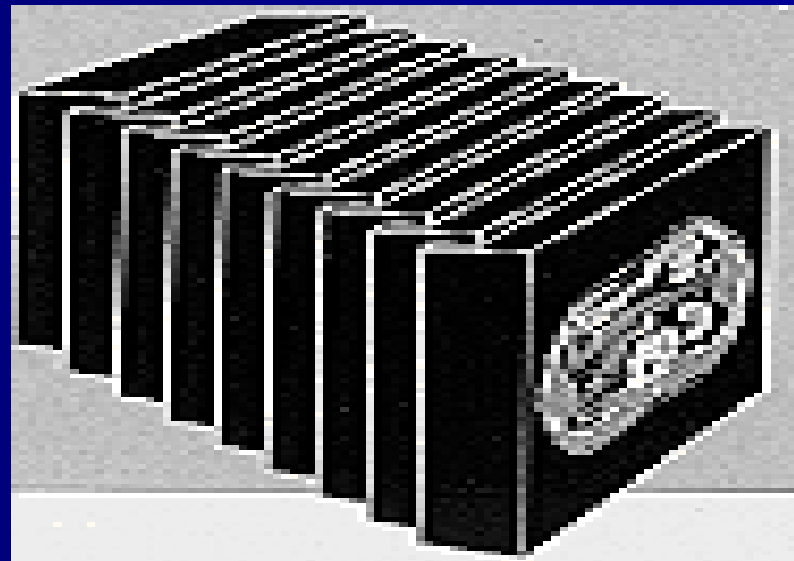
helical x-ray tube path around patient

Continuous data acquisition

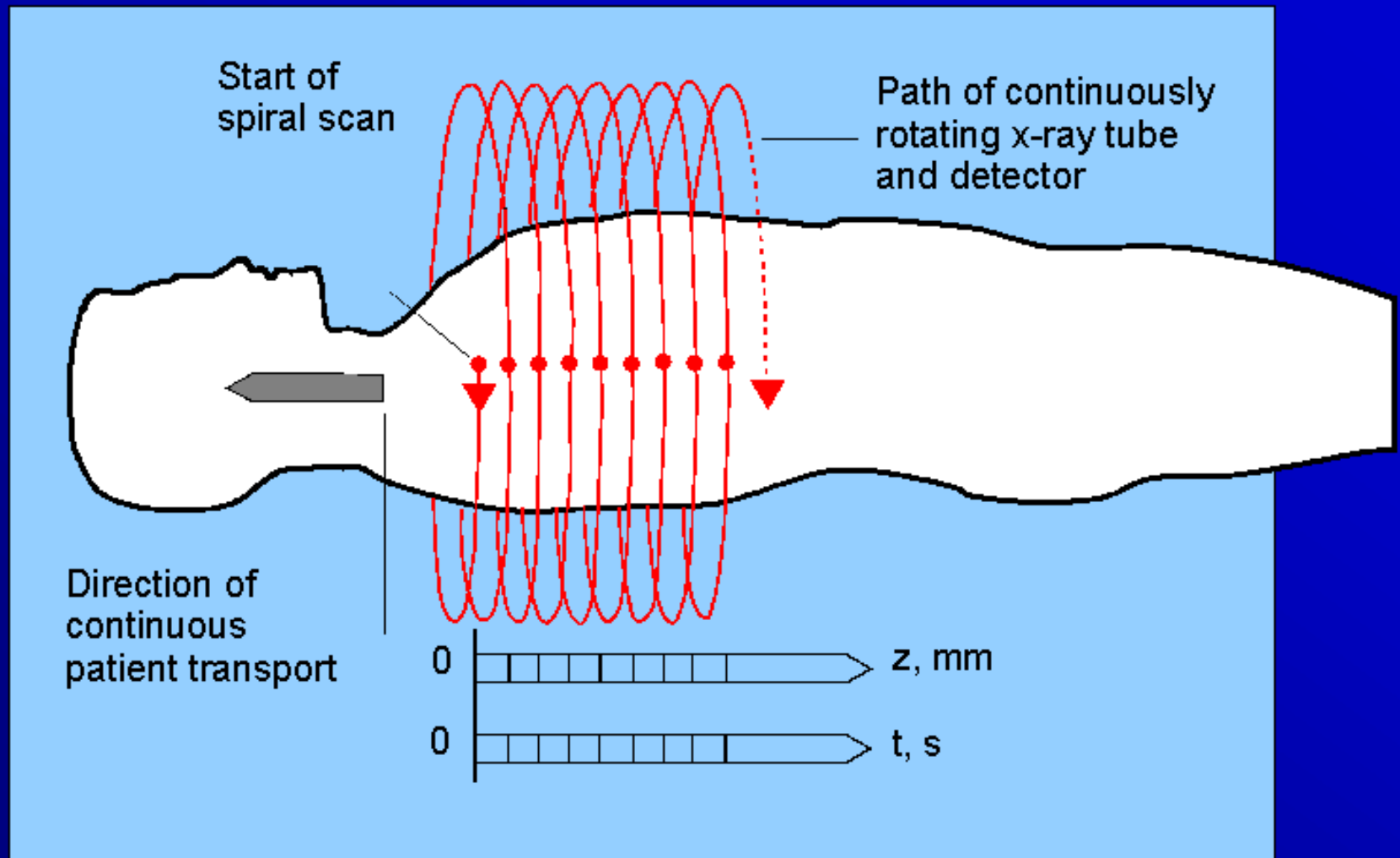


Reconstruction of arbitrary slices (either contiguous or overlapping) within the scanned volume

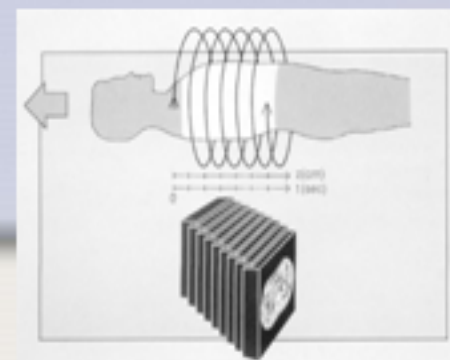
Distance between the slices is called Increment



Spiral CT: Scanning Principle



Spiral (helical) CT



Spiral CT and Spiral multislice CT:

Volume acquisition may be preferred to serial CT

- **Advantages:**
 - **dose saving:**
 - reduction of single scan repetition (shorter examination times)
 - replacement of overlapped thin slices (high quality 3D display) by the reconstruction of one helical scan volume data
 - use of pitch > 1
 - **no data missing as in the case of inter-slice interval**
 - **shorter examination time**
 - to acquire data during a single breath-holding period avoiding respiratory disturbances
 - disturbances due to involuntary movements such as peristalsis and cardiovascular action are reduced

Limitation:

- Length cable
- Image processing

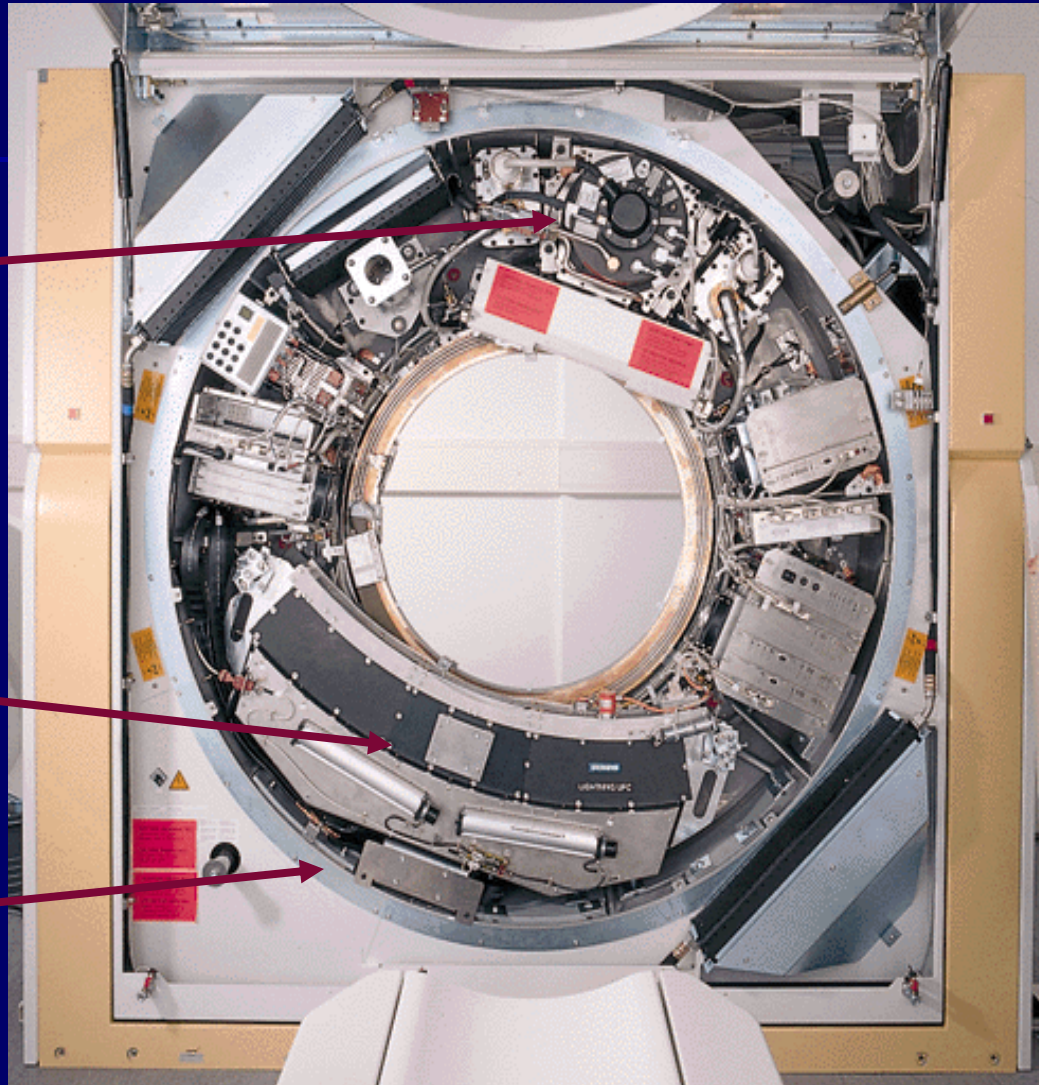


A Look Inside a Slip Ring CT

X-Ray
Tube

Detector
Array

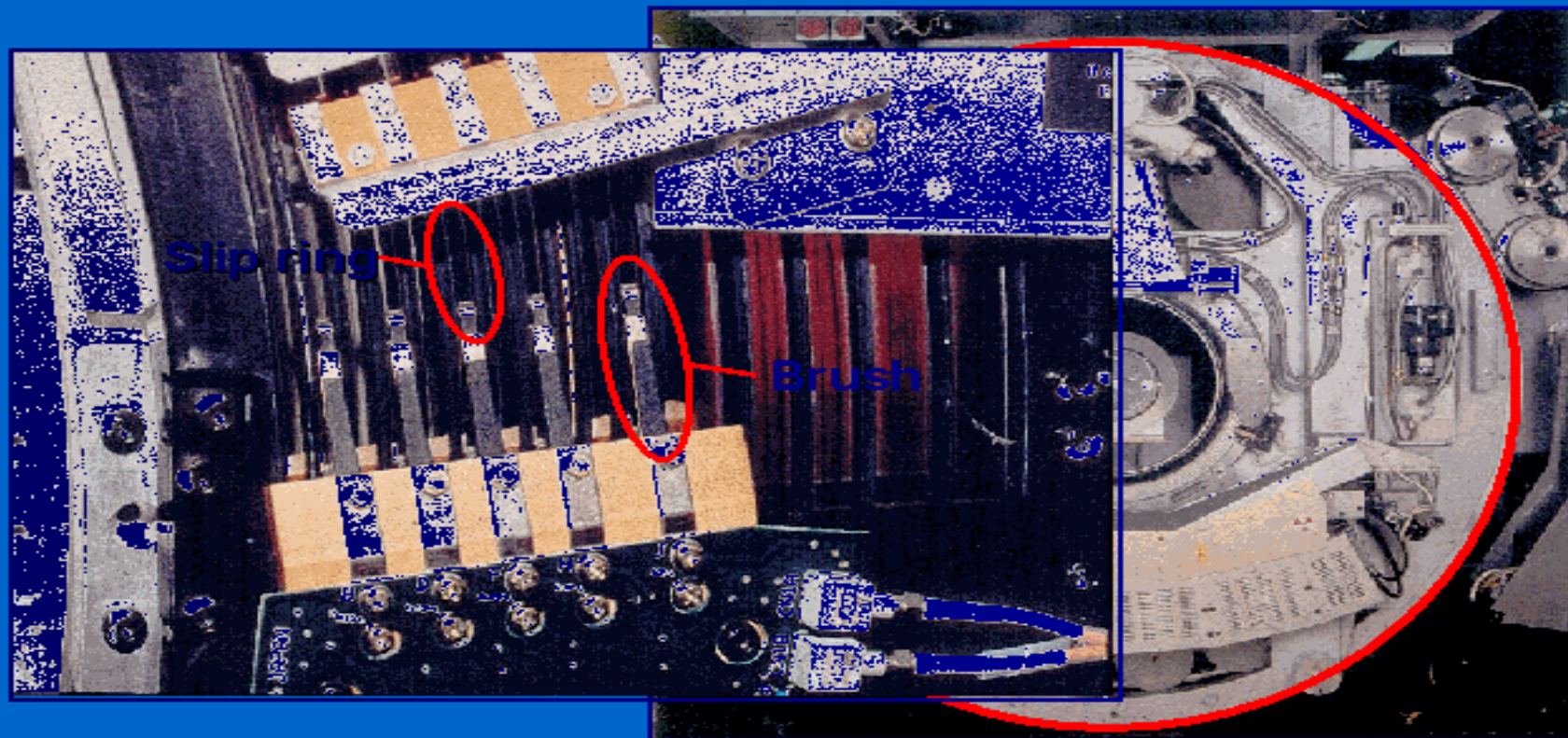
Slip Ring



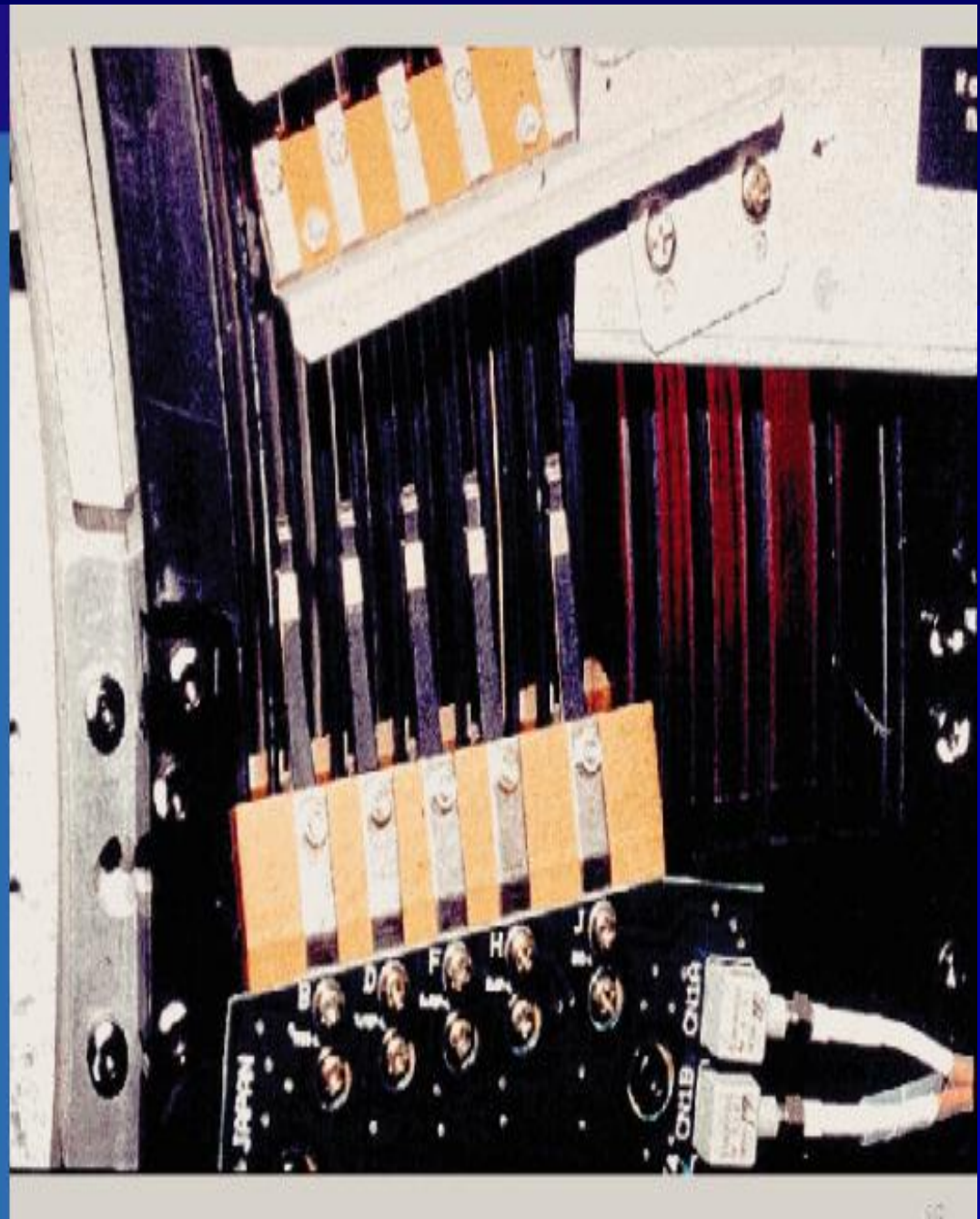
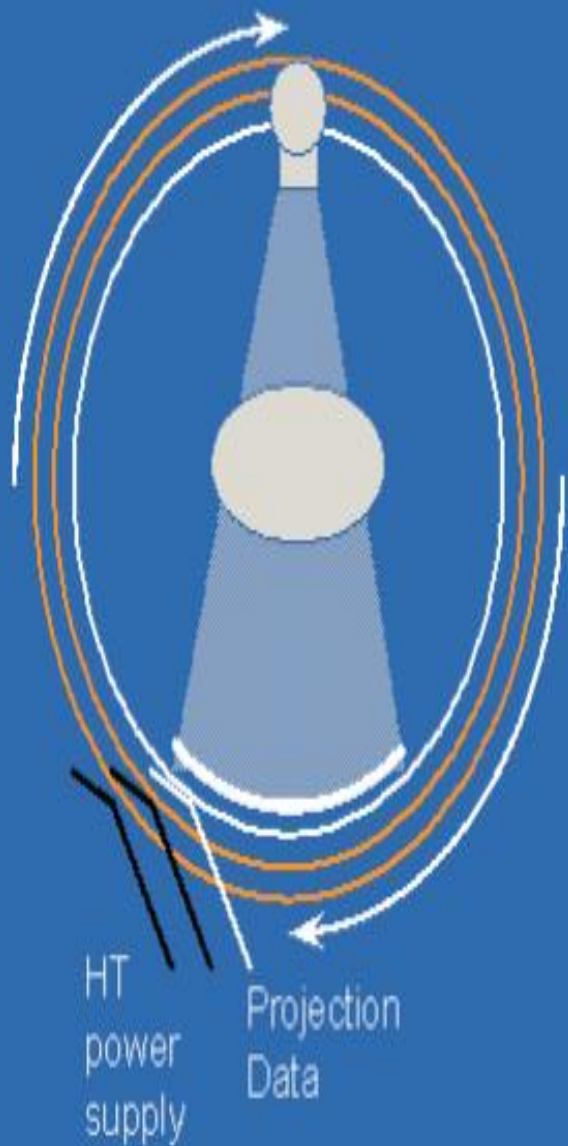
Note:
how most
of the
electronics is
placed on
the rotating
gantry

SLIP RINGS

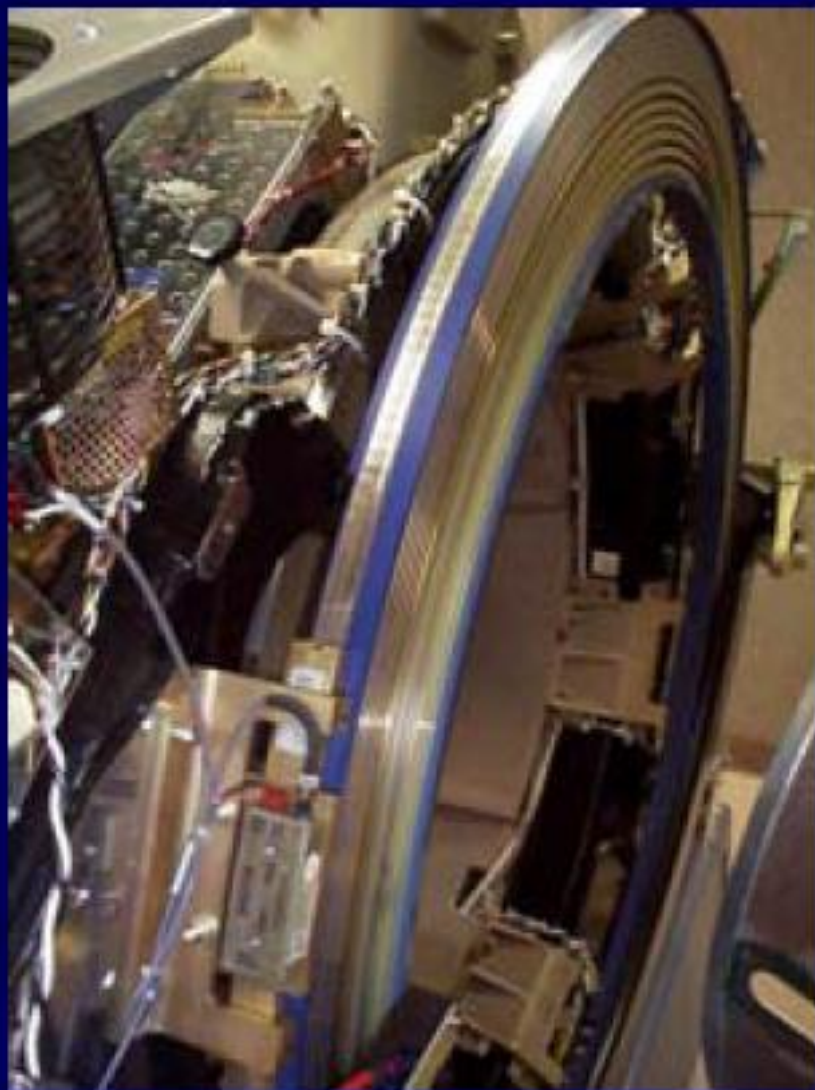
Slip rings – allow continuous gantry rotation



Slip-ring scanning



Slip-ring



Requirements for data acquisition



1- **Continuously** rotating scanner base
on slip ring technology



Slip-ring Scanner

2- *Continuously* couch movement



3-Increase in load ability of the x-ray tube, capable of delivering at least 2000 MA per revolution continuously time it takes to scan the volume of the tissue throughout



- 4- Increased cooling capacity



5- Spiral/helical weighting algorithm

$$\begin{aligned}1 \times 8 + 1 &= 9 \\12 \times 8 + 2 &= 98 \\123 \times 8 + 3 &= 987 \\1234 \times 8 + 4 &= 9876 \\12345 \times 8 + 5 &= 98765 \\123456 \times 8 + 6 &= 987654 \\1234567 \times 8 + 7 &= 9876543 \\12345678 \times 8 + 8 &= 98765432 \\123456789 \times 8 + 9 &= 987654321\end{aligned}$$



- 6- mass memory buffer to store the vast amount of data collected



What is Spiral Scan? -- just 4“C”

- **C**ontinuously rotating tube/detector system
- **C**ontinuously generating X-ray
- **C**ontinuously table feed
- **C**ontinuously data acquisition



Question:



