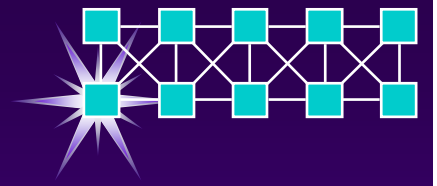
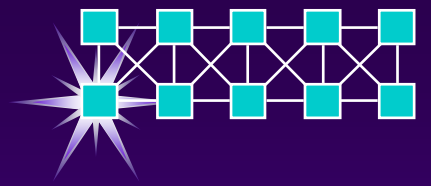
Medical Imaging Systems



- Radiography
- **Computer Tomography**
- Magnetic Resonance Imaging (MRI)
- Nuclear Medicine
- Ultrasound
- Electrical Impedance Tomography
- Breast Thermography
- Others (**Elastography, Spectroscopy, Ophthalmology**)

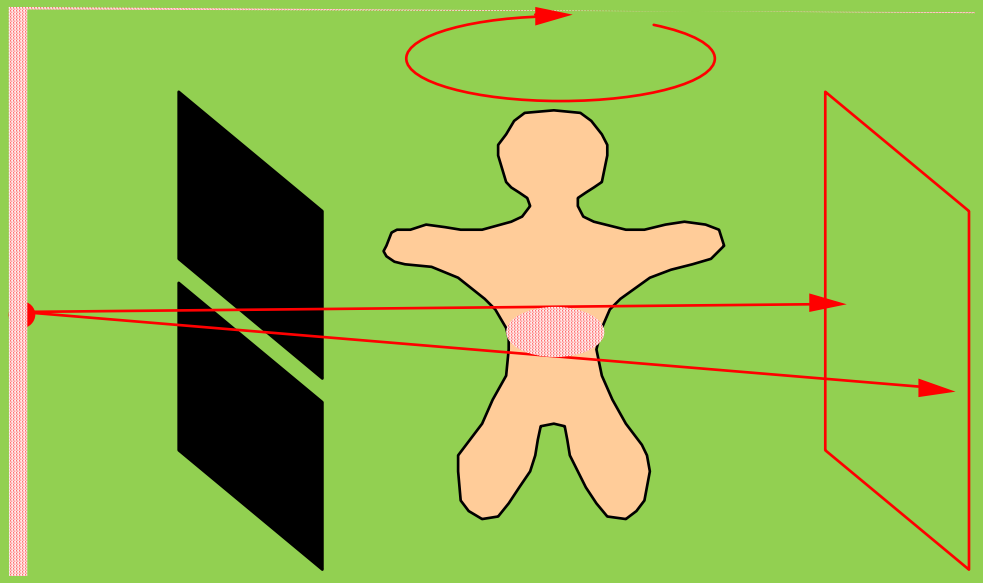


Computerized Tomography

Imaging of a cross sectional slice of the body using X-rays.

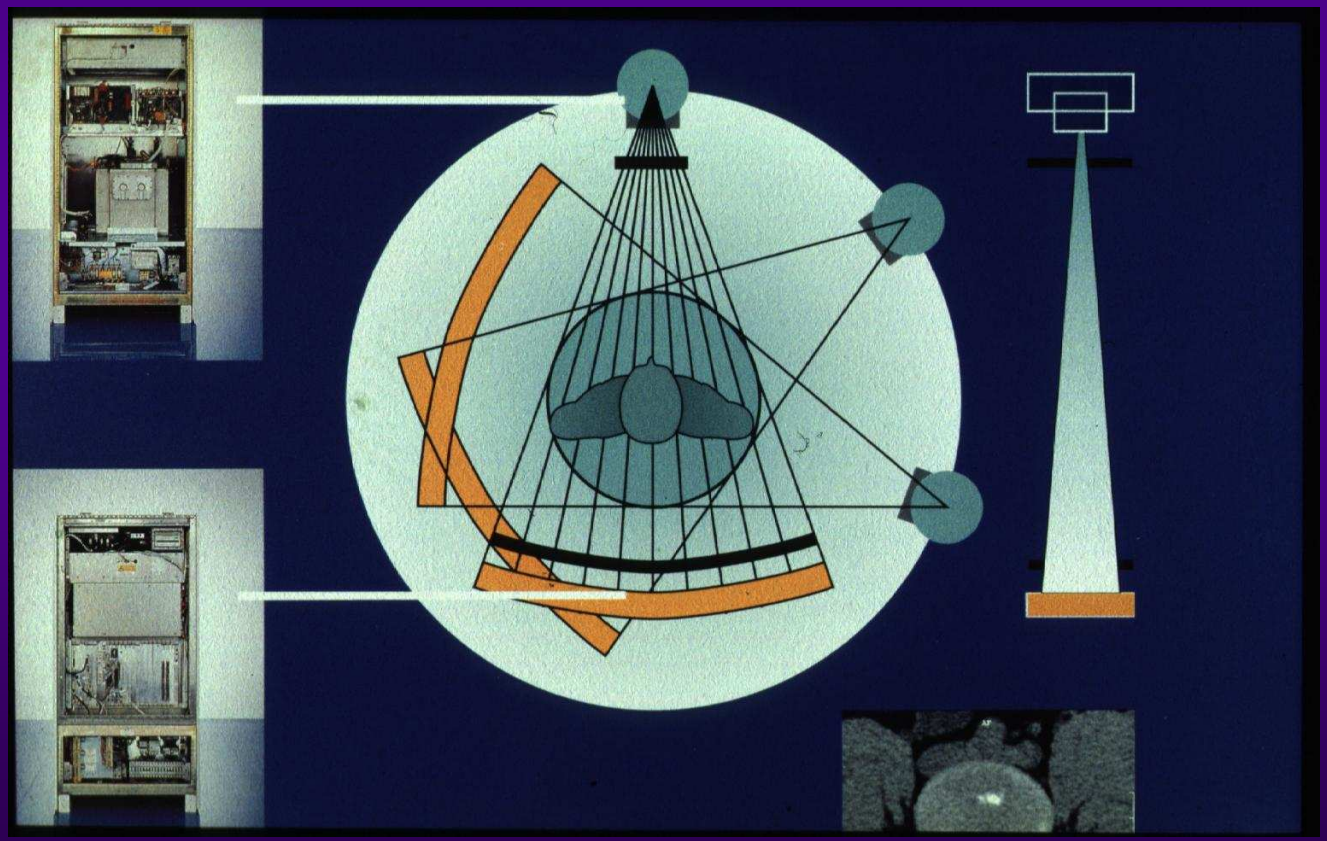
Invented by Dr. G. N. Housfield in 1971.
Received the Nobel prize in medicine in 1979.

Computer Tomography: How It Works

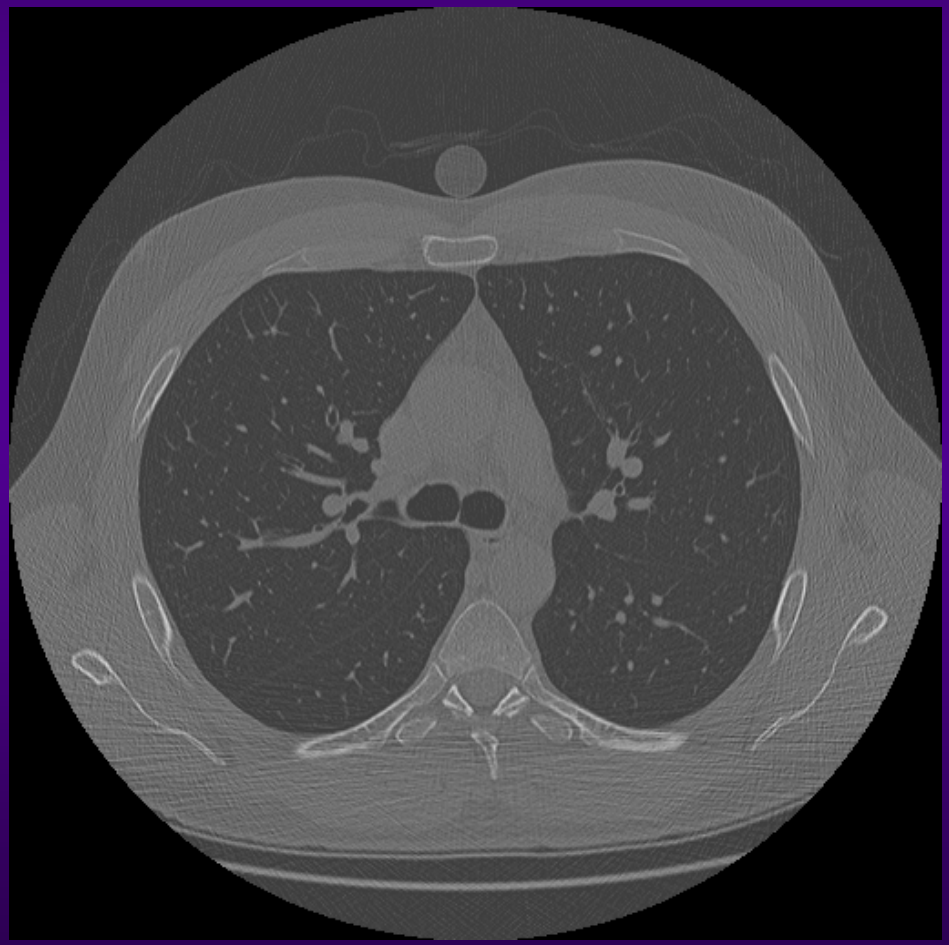


Only one plane is illuminated. Source-subject motion provides added information.

Reconstruction of cross-sections from projections

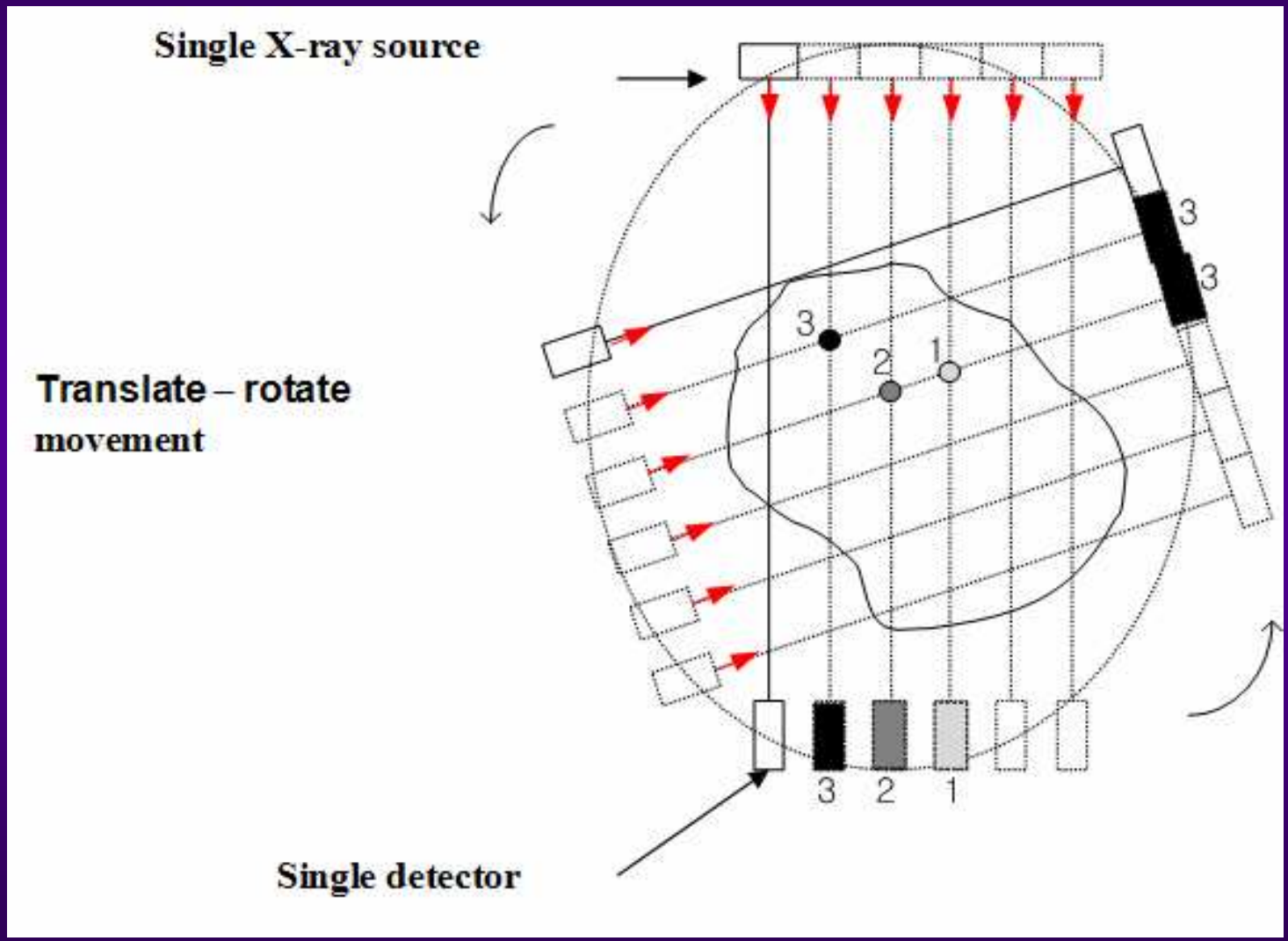


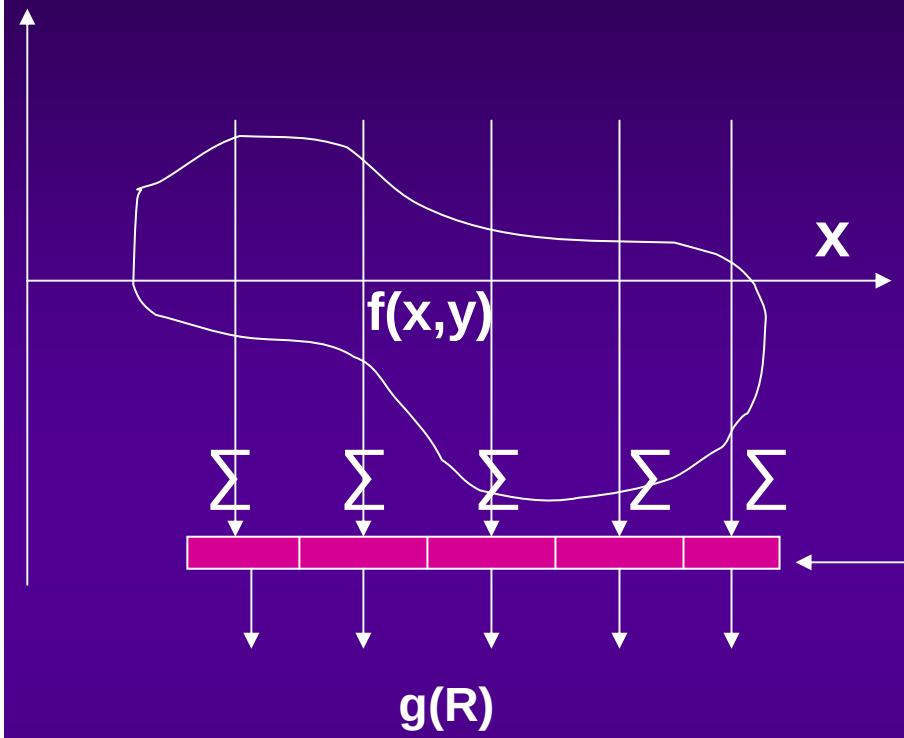
Sample CT Images



CT section upper abdom

First generation CT



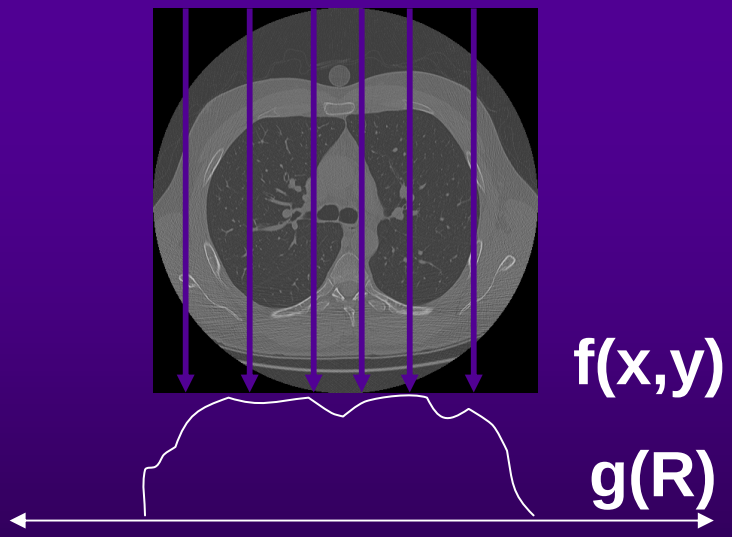


g(R) = CT detector array output

Like X-ray,
CT measure line integrals
(Radon Transform)

$$g(R) = \int_{y=-\infty}^{y=\infty} f(x,y)dy$$

Radon Transform 1917
Central Section Theorem - Bracewell
The transform of each projection forms a line, at that angle, in the 2D FT of f(x,y)



$$g(R) = \int f(x,y)\, dy$$

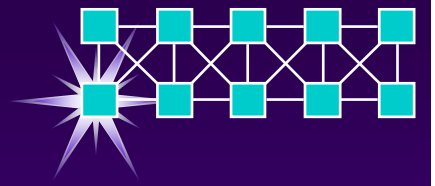
EXAMPLE of Localization using Backprojection

	EW 1	EW 2	EW 3	EW 4	EW 5	EW 6	EW 7	EW 8	EW 9	
NS1										
NS2										
NS3										
NS4										
NS5										
NS6										
NS7										
NS8										
NS9										

BATTLESHIP

	EW 1	EW 2	EW 3	EW 4	EW 5	EW 6	EW 7	EW 8	EW 9	
NS1										
NS2										
NS3										
NS4										
NS5										
NS6										
NS7										
NS8										
NS9										
	1	1	1	0	1	1	1	4	0	

BATTLESHIP

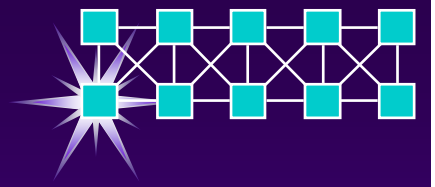


	EW 1	EW 2	EW 3	EW 4	EW 5	EW 6	EW 7	EW 8	EW 9	
NS1										
NS2										
NS3										
NS4										
NS5										
NS6										
NS7										
NS8										
NS9										
	1	1	1	0	1	1	1	4	0	

BATTLESHIP

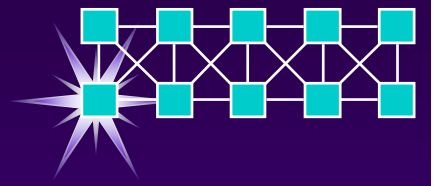
	EW 1	EW 2	EW 3	EW 4	EW 5	EW 6	EW 7	EW 8	EW 9	
NS1										1
NS2										1
NS3										4
NS4										1
NS5										0
NS6										0
NS7										3
NS8										0
NS9										0
	1	1	1	0	1	1	1	4	0	

BATTLESHIP



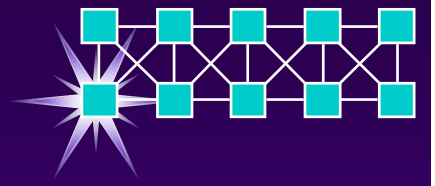
	EW 1	EW 2	EW 3	EW 4	EW 5	EW 6	EW 7	EW 8	EW 9	
NS1	1	1	1	0	1	1	1	4	0	1
NS2	1	1	1	0	1	1	1	4	0	1
NS3	1	1	1	0	1	1	1	4	0	4
NS4	1	1	1	0	1	1	1	4	0	1
NS5	1	1	1	0	1	1	1	4	0	0
NS6	1	1	1	0	1	1	1	4	0	0
NS7	1	1	1	0	1	1	1	4	0	3
NS8	1	1	1	0	1	1	1	4	0	0
NS9	1	1	1	0	1	1	1	4	0	0
	1	1	1	0	1	1	1	4	0	

BATTLESHIP



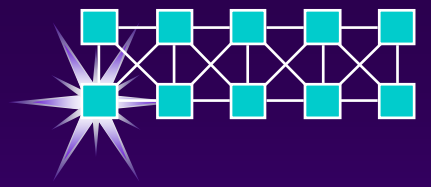
	EW 1	EW 2	EW 3	EW 4	EW 5	EW 6	EW 7	EW 8	EW 9	
NS1	1+1 =2							4+1 =5		1
NS2										1
NS3										4
NS4										1
NS5										0
NS6										0
NS7			3+1 =4							3
NS8										0
NS9										0
	1	1	1	0	1	1	1	4	0	

BATTLESHIP



	EW 1	EW 2	EW 3	EW 4	EW 5	EW 6	EW 7	EW 8	EW 9	
NS1	2	2	2	1	2	2	2	5	1	1
NS2	2	2	2	1	2	2	2	5	1	1
NS3	5	5	5	4	5	5	5	8	4	4
NS4	2	2	2	1	2	2	2	5	1	1
NS5	1	1	1	0	1	1	1	4	0	0
NS6	1	1	1	0	1	1	1	4	0	0
NS7	4	4	4	3	4	4	4	7	3	3
NS8	1	1	1	0	1	1	1	4	0	0
NS9	1	1	1	0	1	1	1	4	0	0
	1	1	1	0	1	1	1	4	0	

BATTLESHIP

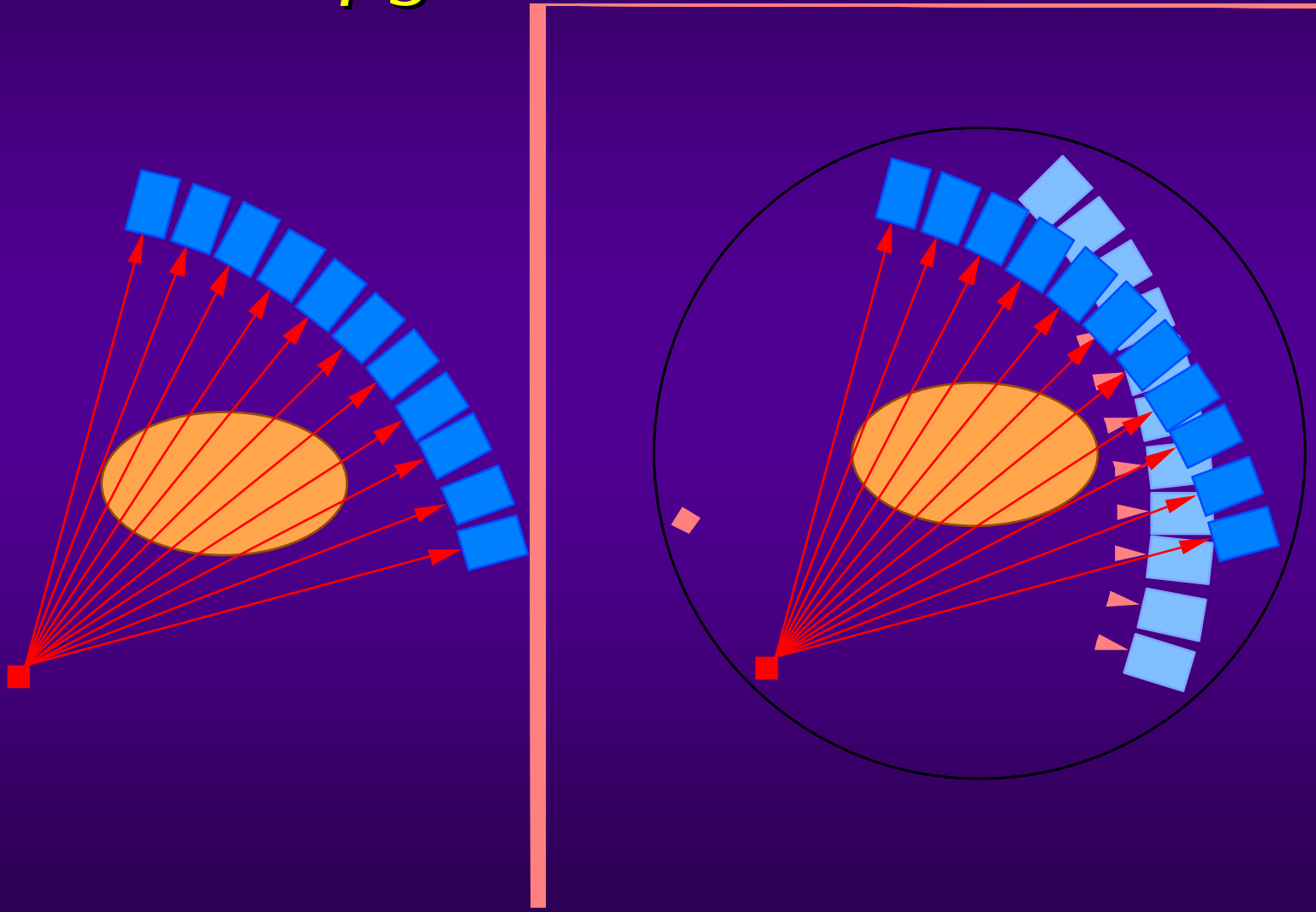


	1	2	3	4	5	6	7	8	9	
A										
B										
C										0
D										0
E										1
F										1
G										1
H										0
I										0
										1
	1	2	1	1	0	0	0	0		1

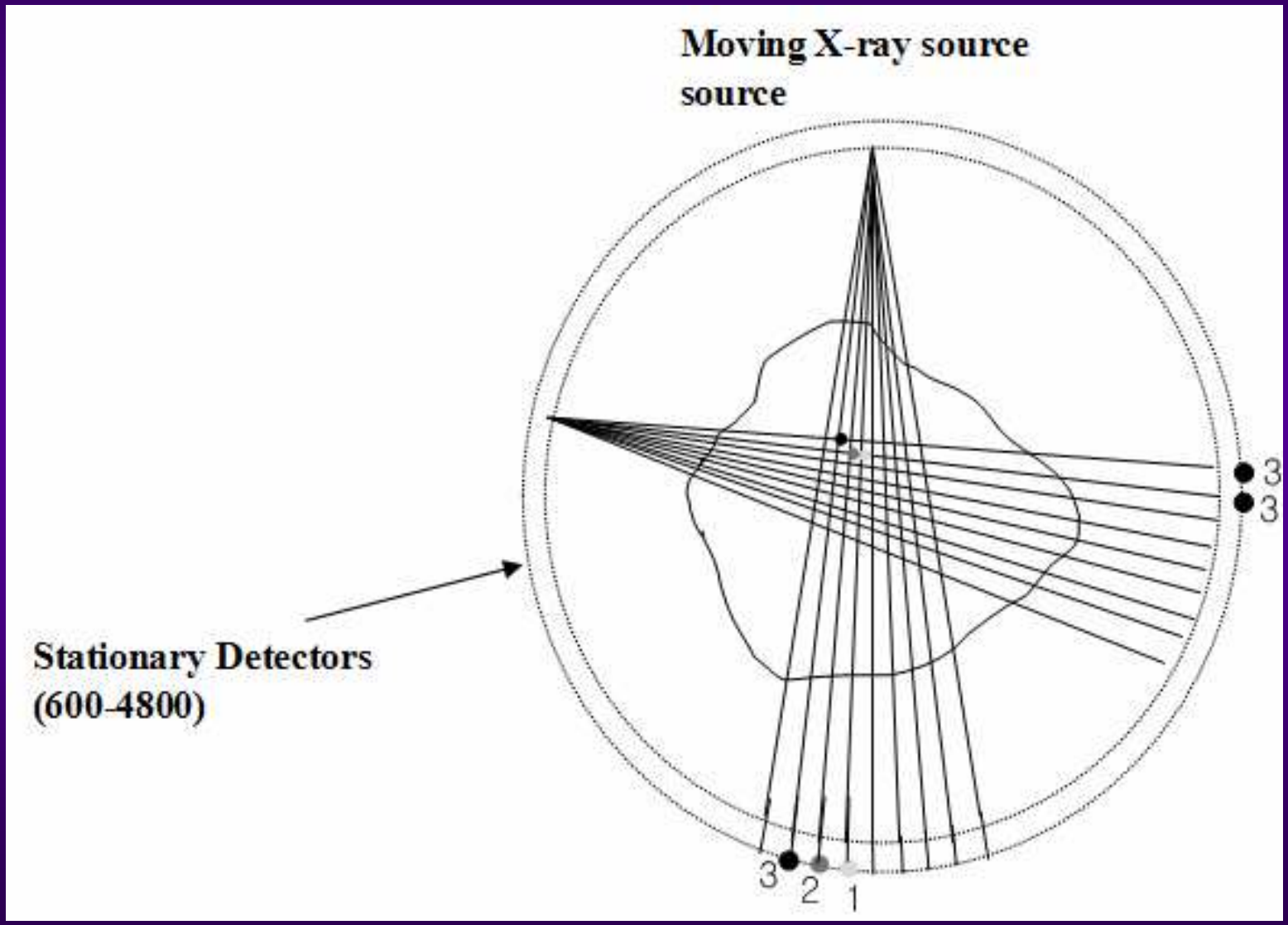
BATTLESHIP

	1	2	3	4	5	6	7	8	9		
A	2	2	3	2	3	2	2		2		1
B	2	3	3	2	2	2	3		2		1
C				4	5	6	6		6		4
D	3	3	2	1	3	3	3		2		1
E	2	1	1	1	2	2	3	5	1		0
F	1	1	2	1	2	3	2	5	0		0
G	4	5	5	4				7	3		3
H	2	2	2	2	2	2	1	4	0		0
I	2	2	3	1	2	1	1	4	0		0
	1	1	1	0	1	1	1	4	0		

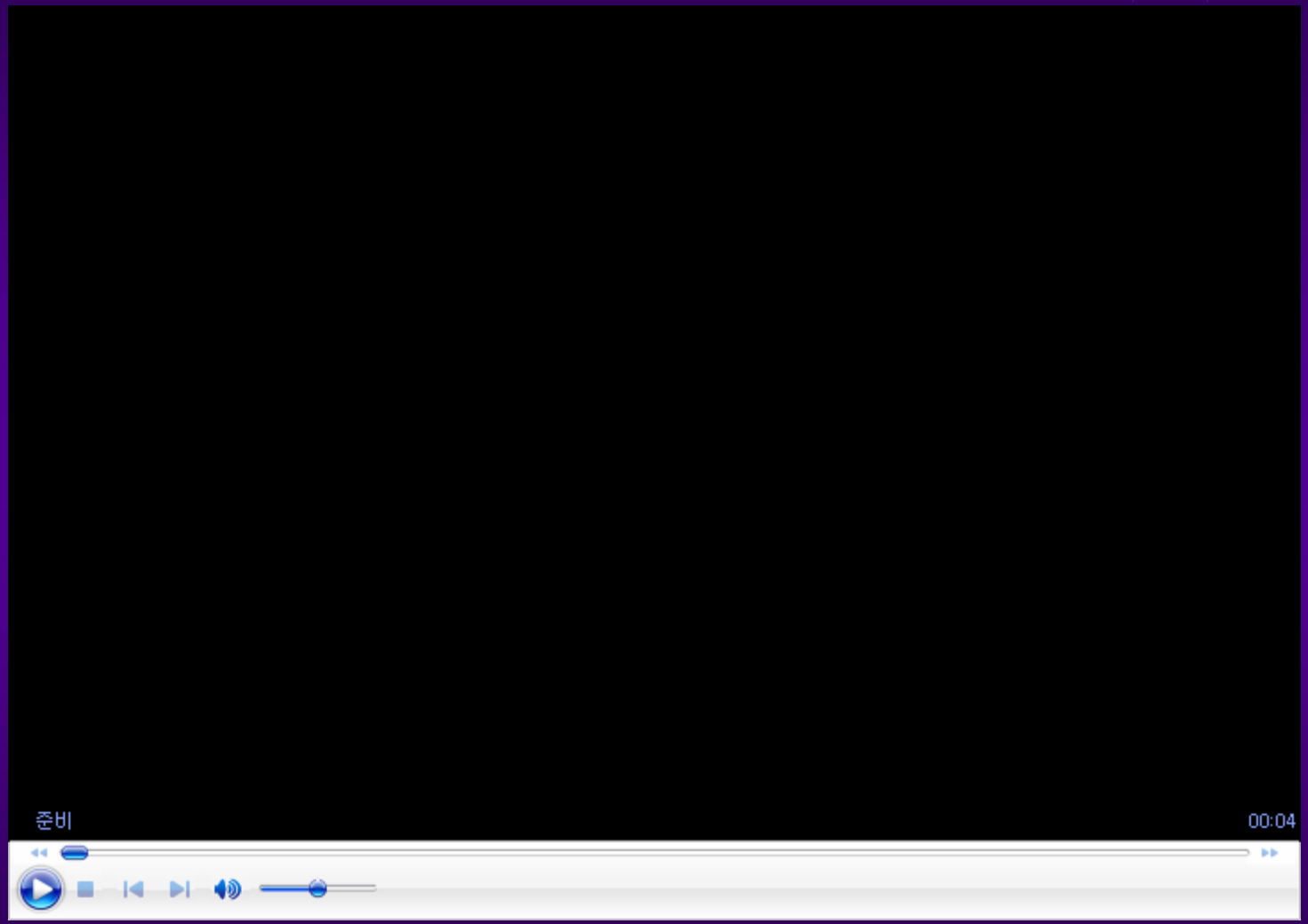
Fan-Beam Computer Tomography : Better Configuration



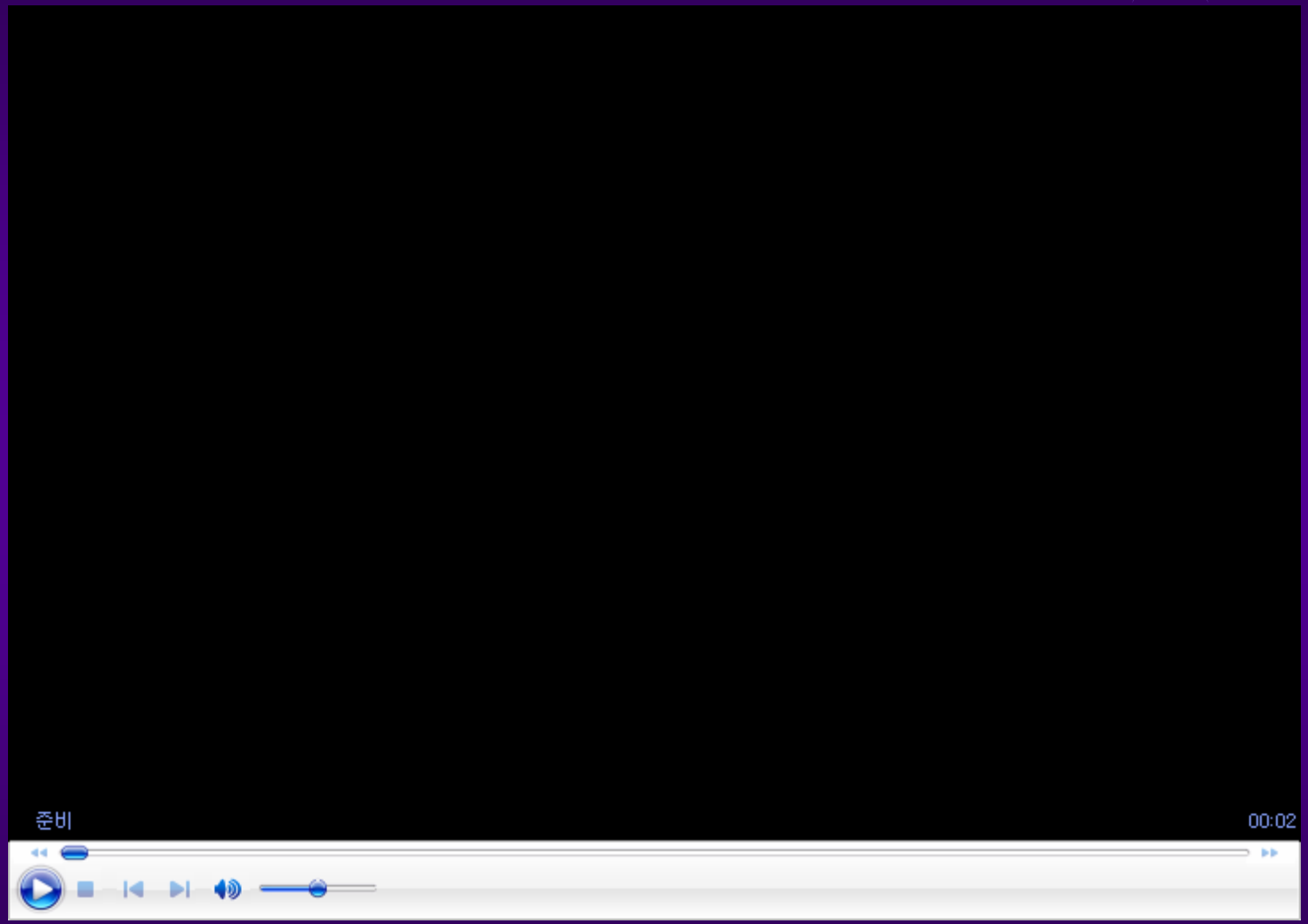
4th generation CT Fan beam, stationary detectors.



Basic CT Scan

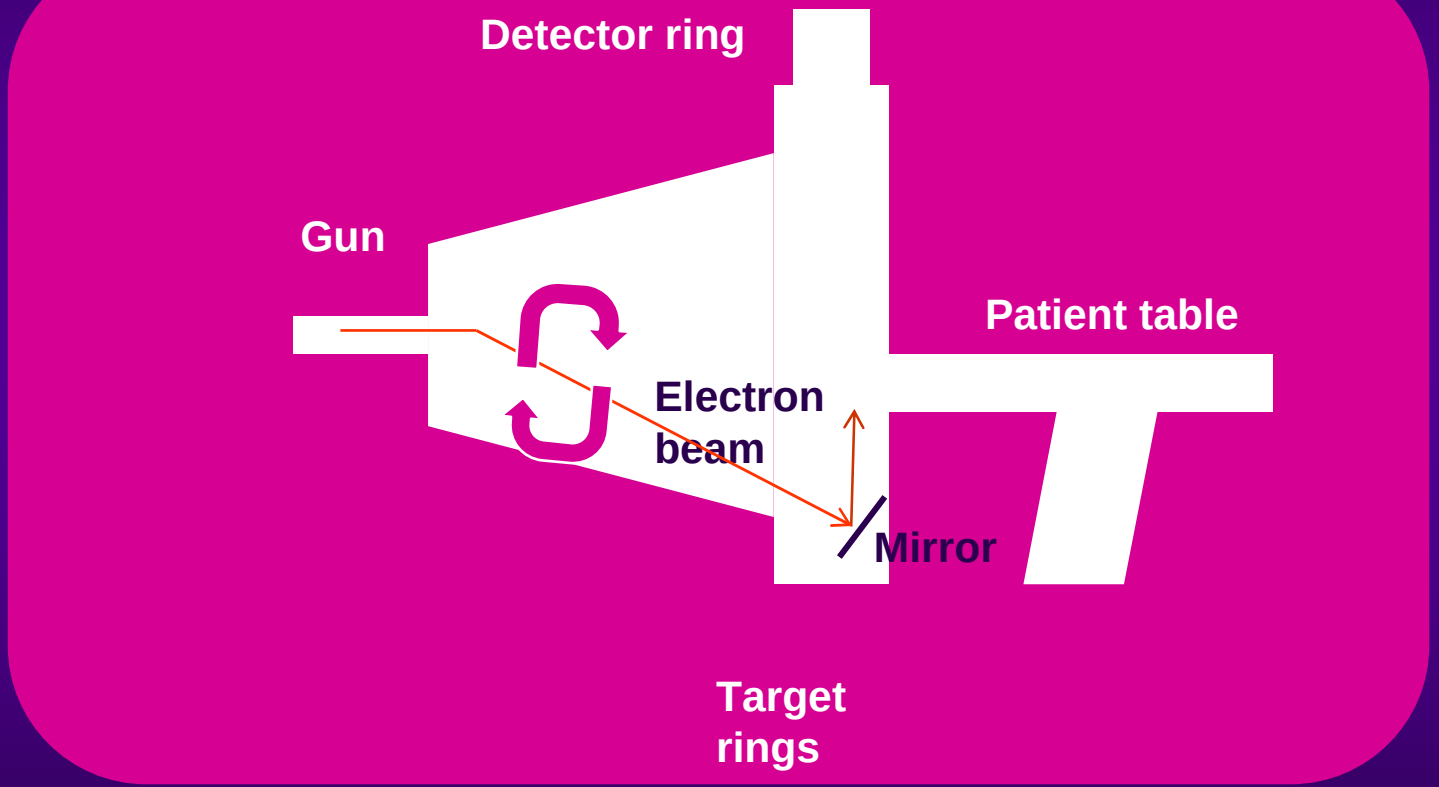


CT Back Projection and Forming Image



Fifth generation CT

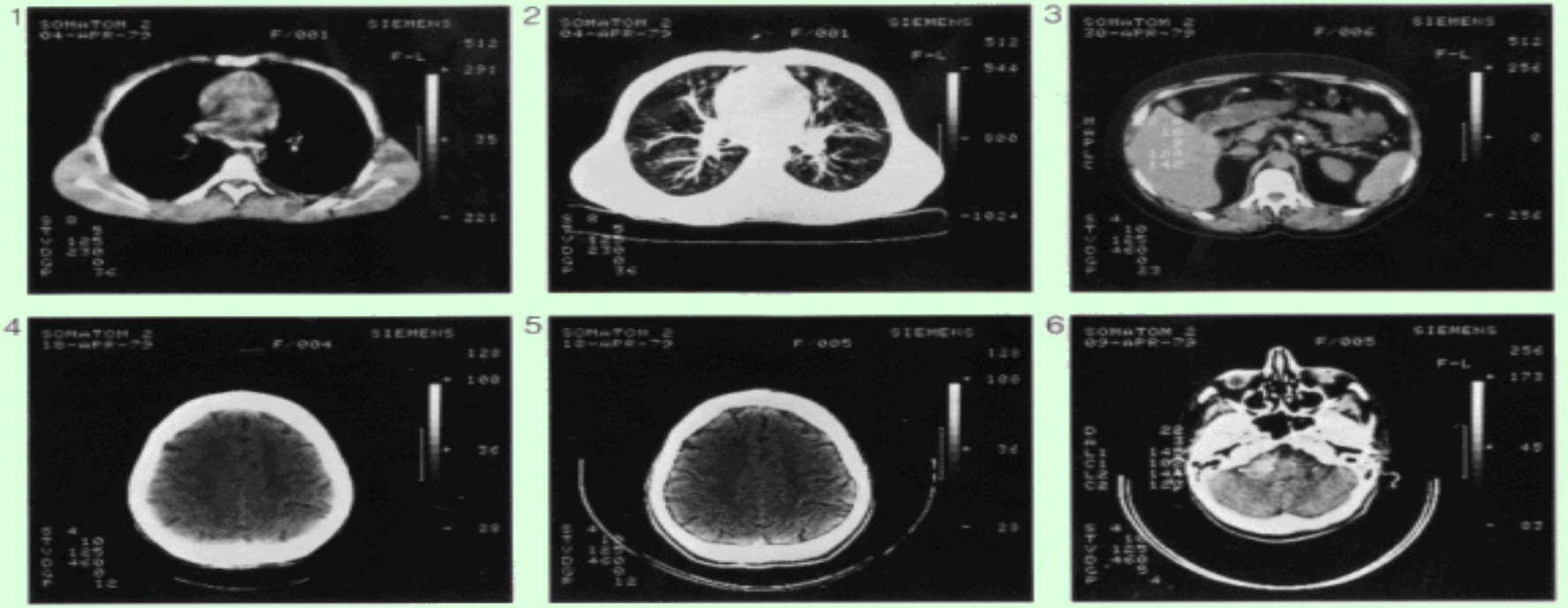
(Image data are acquired in as little as 50 mSEC).



There is no mechanical motion involved.

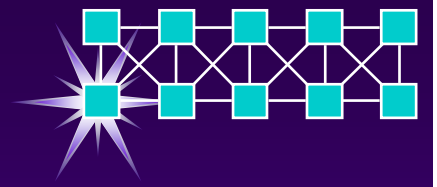
Example of cross-sections through several parts of the body:

skull, thorax, and abdomen, obtained by computed tomography.



abdomen **thorax** **skull**

Filtered backprojection



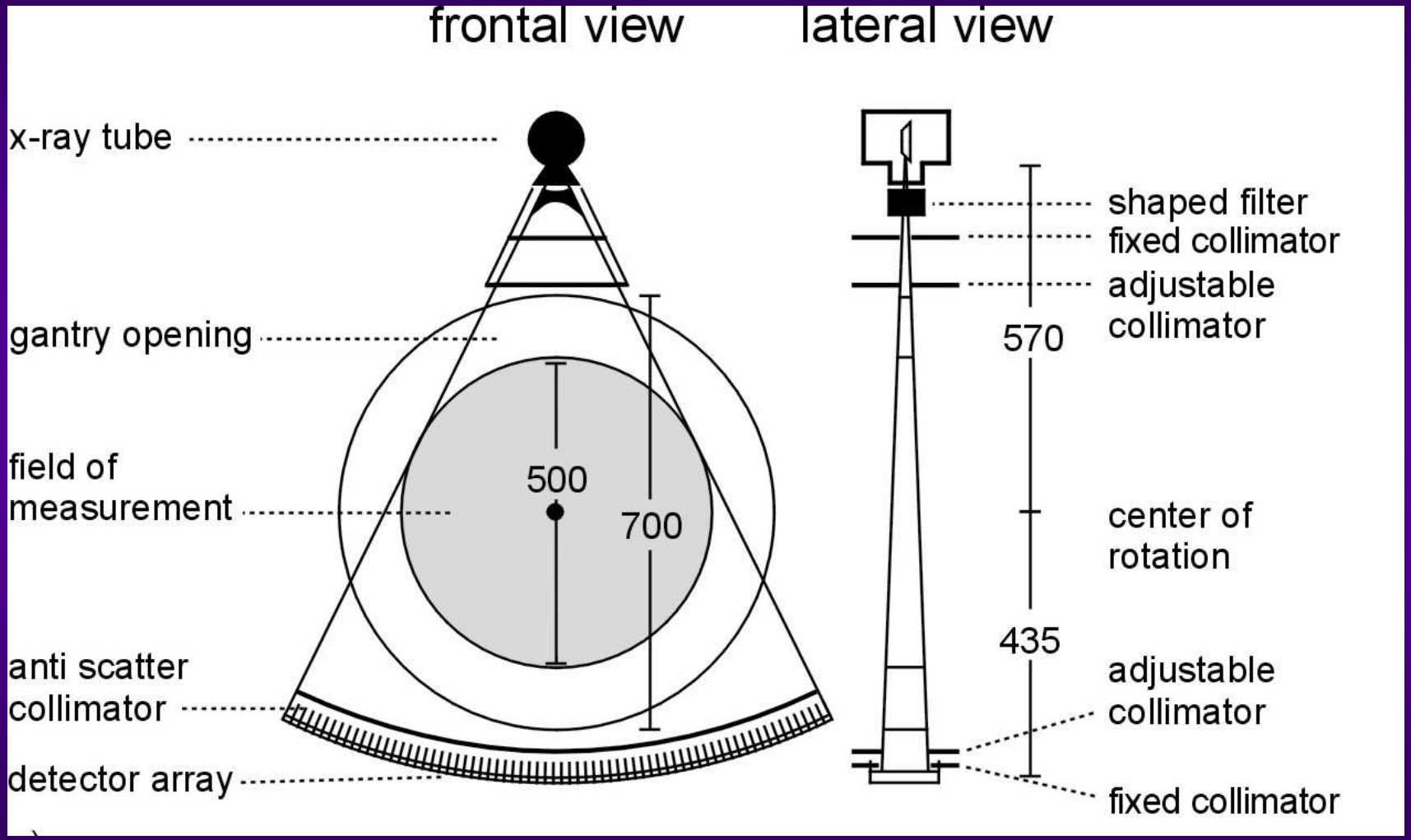
- **Spatial domain Filtering:**

$$p'(t,\theta) = p(t,\theta) \otimes h(t)$$

- **Frequency domain Filtering:**

  $p(\nu,\theta)$=FT { $p(t, \theta)$ }

What are inside the gantry?



Schematic Representation o f the Scanning Geometry of a CT System

Scanner with covers

Scanner without covers